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FOUR CATEGORIES OF SPECIES.

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THERE are at least four different sorts of species, so called, involved in the study of as many theoretically related, but also theoretically and practically distinct, taxonomic problems. The result of indiscriminately confusing these problems and their specific criteria has been the occasion of many destructive criticisms of systematic biology. Such objections are frequently valid, but not as uniformly pertinent, since they rest, in reality, on faulty analysis rather than upon any inextricable difficulties or logical inconsistencies connected with the several tasks of biological taxonomy.

To vary somewhat the familiar comparison of organic nature to a tree and its branches, evolutionary theories permit us to think of life rather as originating at a point which, by the accretion of countless successive individuals, has become the center of a sphere upon whose surface existing vitality appears as islands in the sea of nonexistence. The section of such a sphere would differ from that of the earth in that the oceans would have enormous depth, for the solid core would separate from near its center into numerous and repeated divisions.

It is perhaps conceivable that life might have reached variety and complexity without accompanying segregation into limited

groups of similar individuals, in which case all the circumferential possibilities of form and structure would have been realized, with a result comparable to a uniformly solid sphere. Arguments and phylogenies are often based on this assumption, that all organic types have been connected by intermediate forms; but there is no valid reason to suppose that more than very few of such theoretical possibilities have been projected into the actual; the oceans of our vital globe are not only deep, but are in overwhelming proportion to the space otherwise occupied. Segregation has everywhere accompanied differentiation in structure, and the forms which might have maintained connection between the various branches of life are not in most cases to be thought of as extinct; they have never come to expression, never existed.

Having been accustomed to consider organic types as forming connected series, those who have approached systematic biology from the paleontologic standpoint have been especially prone to overlook the distinctions which arise from the fact that all such series are, in fact, lineal, and that their successive members have always been separated by chasms of nonexistence, so to speak, from all except phylogenetically related forms. Moreover, the points of actual contact with these last are few and momentary if the extent of biological history be taken into account; a grave fallacy is accordingly involved in the theory of classification which attempts to render nature at large comprehensible through methods logically applicable only to phylogenetic series. From the practical standpoint it is as though topographic expedients were limited to the numbering of houses. As such designations are of no utility unless streets are also known, so is the lineal method of classification of use only in dealing with ascertained series. Notwithstanding the theories of interlacing phylogeny which some authors have propounded, it may be asserted with confidence that the analogy of streets and numbers has but a limited application in nature. There are no cross-thoroughfares; all the lines radiate in general from a center, and while they may sometimes become closely parallel, we have as yet no adequate evidence that under natural conditions they ever reunite after more than the briefest divergence.

The species of the paleontologist is, then, with reference to the other members of its line, an arbitrary division of a continuous series of gradually changing forms. The fact of established sequence will go far to prevent confusion, and the purposes of classification are served by such a knowledge of forms and characters as will make possible the reference of a given individual to its proper place in the series. Illogical procedure may be charged against any attempt at applying these concepts or methods outside of the lines of established, or at least suspected, phylogeny.

The termini of such of the paleontological series as have not become extinct are the subject-matter of the biology of to-day, in contradistinction to that of the past or the future. Returning to the former analogy, it may be insisted that as the accretions of the life of previous ages have been built up on distinct lines, so is existing life manifested in assemblages of similar individuals, which are obviously distinct collectively. The forms which would be required to connect them do not exist, and we shall make little true progress in the knowledge of organic nature until we abandon the attempt at arranging living organisms in continuous series. With rare exceptions their relationship must be traced through the more or less remote past. In one sense all life may be thus connected, and absolute lines between groups of specific or higher rank are forever impossible; but in another and equally important sense groups of living organisms may be looked upon as separate and independent, though collective, entities. The study of geography has not been abandoned because of the discovery that all land is connected by the ocean bottom, nor is the topography of a series of islands neglected because soundings prove that they are peaks of a submerged mountain range. No naturalist denies the existence of clearly defined and easily recognizable specific groups, but the difficulty experienced in attempting to resolve the more nebulous parts of nature has sometimes blurred the eyesight of the systematist. In some generic archipelagoes the specific islands stand out prominent and distinct, like the members of the Canary and Hawaiian groups; while in others they are painfully similar and are separated only by narrow,

shallow, and tortuous channels, like the Florida Keys. These last are, indeed, a cartographer's nightmare comparable to the species of *Aster* and *Sphagnum*. But whether the naturalist's theories help or hinder, his descriptive task will not be complete until the facts of nature have been recognized and recorded, until all the islands have been located and mapped. That this work is in a confused and backward state is partly due to the conceptual fallacy of species and genera, which has led us to attempt to map the islands without securely locating them by the designation and preservation of types.

To divide a continuous series of forms into "genera" and "species" is a thoroughly artificial process analogous to the marking of feet and inches on a measuring rod, and is one of the instances where the naturalist may be said to "make" the "species." The specific islands of living organisms are, however, not made, but discovered by the systematist, and located, not primarily with regard to their disposition in an ancestral series, but with reference to other separate groups. Whether a specific island is large or small, circular or irregular in shape, is not subject to our determination; and the naturalist who expects to apply throughout nature a general concept of species based on the "size" or "weight" of characters is about as well equipped for his work as a map-maker who should undertake to draw a chart of the Florida Keys without other tools than a circular die. With such an implement he could in a general way indicate the location of a few well-separated islands like the Canaries, but the other task is practically impossible.

Although chronologically the first, the problem of systematic paleontology, on account of the fragmentary nature of its material, must depend largely upon the results gained in the study of existing forms. Isolated fossils may be classified, for the sake of convenience, in so-called species and genera in a manner analogous to that used with living types; but when any approximation to a complete phylogenetic series can be made out, that method is no longer logically applicable. The chasms which separate species in the present do not interrupt the unbroken line of ancestry which stands below every existing type,

and to locate a particular point in a continuous series of this kind is manifestly a different problem from that of finding the island which is its extremity. The necessities of the first case are met by observing the appearance, development, and perhaps the decline of some important structure, such as a tooth. The line of natural succession is the important fact, and the classification, as far as there is any, is here of necessity artificial, touching at only one point, that of living forms, which lies in a distinct plane. It is only when considered with reference to their own horizons that fossil species are distinctly comparable to the specific islands of to-day; and to fail to consider the breaks in the horizontal series, because the vertical series is theoretically continuous, is one of the more important instances where a confusing element has been unnecessarily and illogically introduced. It is one task of taxonomy to recognize the facts of the present; and this need not be complicated, but should rather be assisted, by a knowledge of what has been or a suspicion of what may yet be. Nor is it necessary to be frightened by the captious warning that the species now existing will give place to something different to-morrow. The "now" is at least sufficiently extensive for our purposes. As to the coming change, posterity will not know its rate nor direction unless we certify the details of the present reality. The careful description and preservation of types, instead of works of supererogation, are of the utmost importance, not as means of specific limitation, but as giving fixed points about which accretions of knowledge may gather. The recognition and adequate designation of natural species or higher groups are frequently matters of extreme difficulty, requiring extended and careful study which the agnostic naturalist jauntily avoids, sometimes by professing interest in "more important" problems. To tell from a few specimens whether a new form represents a distinct species or not is frequently impossible, and opinion must be provisionally based on the analogy of better known relatives; but this initial difficulty in no way affects the practicability of the subsequent settlement of the question by more extended observation.

Whether the segregation of a new group has been accom-

plished seems to be a matter of indifference to some ultra-progressive naturalists. It is as though a geographer, having learned that a certain region is slowly subsiding, should proceed to name the hills as islands, and publish his book revised for the next geologic period. Such a procedure would be, to say the least, misleading, both for the present and future generations. This is the third type of "species," very much in evidence at the present day. Although the designation by name of the various prominences or arms of a diversified island is desirable, even before the expected separation occurs, the prophetic tendency should, in the interest of historical accuracy, be curbed to the extent of distinguishing in category between groups which are already segregated in nature and those which are not. One naturalist refers to an entire island as a species, while another divides it into numerous parts which he still calls "species." Now these parts may be as abundant in individuals, and their extremes may show differences even greater than those separating completely isolated species, but by treating them as already distinct we ignore the existence of intermediate forms and proceed as though degree of apparent difference were an index of segregation or a taxonomic substitute for it. The theory that the formation of species through differentiation and segregation is proceeding continuously throughout nature has too often served as a warrant for a complete confusion of issues, with the natural result that some writers have shown more frankness than perspicacity in assuming the position that species are among the things "past finding out."

As if to solidify the confusion and justify this attitude, the naturalist is called to deal with a rapidly increasing number of man-made perversions, or at least diversions of nature. We assemble from different continents species of undoubted distinctness and absolute segregation in nature, and produce hybrids which nature would never have formed and would not now permit to exist except under human auspices. Some natural species, too, have shown themselves wonderfully susceptible of change through the influence of selection, so that the honest advocate of a general specific concept finds himself under the

necessity of recognizing species and genera created by the gardener and poultry fancier. Taking as a criterion of amount the minute differences by which some distinctly segregated species, such as those of *Antennaria,* are distinguished, the impartial botanist of conceptual proclivities would find himself more than occupied in providing for the scientific recognition of horticultural novelties. With degree of difference as the criterion of classification, the annual increase in the species of the genus *Rosa* would be very considerable, for the divergences resulting from crosses and selection are often as great as those existing between wild species of undoubted validity.

The four types of species may then be enumerated as follows:

1. *The phylogenetic species, a division or section of a line of biological succession.*

2. *The insular or segregated species, the living end of a line of the preceding category.*

3. *The incipient species, preferably known as the subspecies,* which is a subdivision of the second category, being a group of individuals showing distinctive characters and a tendency to segregation, but still connected with other groups by normally existing intermediate forms.

4. *The artificial species, the result of man's interference in nature,* by which the specific islands of the second category have been, as it were, remodeled or connected by causeways or bridges, the natural tendency to isolation and segregation having been reversed through human agency.

In one case only does nature limit the species; in the other three the species are arbitrary in the sense that their boundaries are formal and to that extent conceptual. It were much better if other terms could be made available, so that the designation "species" might be reserved for its original use with the second category. For the third the appropriate term "subspecies" is increasing in favor, while to the fourth there seems to be no good reason why the popular designation "variety" should not be restricted. Even here it is not the absolute degree or amount of difference which determines the desirability of independent recognition for a new form, but the constancy and utility of the differences. It is fortunately still true that

the second category stands forth as by far the most important sense of the term "species," and much confusion and difficulty would have been avoided if it had been consistently restricted to that purpose. But equally loose has been the application of the subordinate designations "subspecies," "variety," "form," and "race." With "amount of difference" as the only criterion, fossils, geographic races, and artificially produced varieties are being catalogued miscellaneously and indiscriminately as "species."

After this failure to distinguish between the different tasks of taxonomy, it is not surprising that the total difficulties have been set forth with as complete an absence of discrimination. It is true, for instance, that some so-called species are arbitrary and artificial concepts, though it is equally true that other species are clearly defined assemblages of similar individuals, the case depending on how we make our terms and how we use them. But it is least certain that any method of procedure is faulty which tends to obscure the various issues and make confusion where none need exist. The limitations of our ignorance are already great enough without unnecessarily increasing them. A student of geography might conclude, after spending some time on the attempt, that it would not be worth while for him to write a monograph of the Florida Keys, but we would scarcely expect him to advertise his failure by composing a treatise to show that geography is an impossibility, since coast lines and landmarks are continually changing. The facts of nature are what we are trying to learn, not systems and concepts. These are, at best, but means, and we should change or throw them aside if they fail of their purpose, instead of allowing ourselves to become entangled in them. Let the term "species" be abandoned altogether, if by so doing we can better realize that the tasks of biological taxonomy are not one, but several, and that each should be approached to the greatest possible advantage without being gratuitously complicated. To trace lines of descent and be able to locate each individual in its proper place is a work quite distinct in plan and execution from the mapping of the islands of life as they lie in the sea of nonexistence. The topography of individual islands is

a subject of extreme interest, and it is perhaps even more important to record and make accessible all knowledge gained regarding the behavior of organized nature under the moulding hand of men. Many facts will have places in the treatment of all four problems, since these touch at many points; but from the standpoint of the execution of the work there is no logical necessity that any one task be rendered more difficult by the existence of the others. In dealing with each of the categories here enumerated, appropriate criteria of so-called species should be sought and persistently followed. If we are to continue to talk of geological or phylogenetic species, we must understand that they can, even in theory, be little more than arbitrary sections of the extinct lines of succession leading up to the living islands of the present, of which the number, form, and relative position can be satisfactorily determined only by directing attention to the question of segregation by space, time, or mutual sterility. To certify on simple inspection whether an individual specimen of a previously unknown plant represents a new species, a subspecies, or a hybrid, is, and must remain, impossible. Notwithstanding much eminent opinion to the contrary, we may insist that the facts of nature and not the concepts of the human mind are the primary objects of biologic study. In this instance, at least, we may rest assured that no refinement of concepts will enable us to know in advance facts which must be ascertained by careful and often by extended observation. The believers in the doctrine of "amount of difference" have, it is true, an apparent advantage in that by the simple application of their individual measuring rods they may be ready to assert, without the embarrassment of delay, that a new individual represents a new species, since it appears "sufficiently different" from others to meet the demands of their "conception of species." If these mental phenomena could be communicated with uniformity to other naturalists, the method would have a practical advantage which it does not now enjoy, since the conception is merely individual, and uniformity of opinion can never be expected. Segregation or its absence is, however, a fact of nature which may be established by careful observation, like other phenomena. If some systematists deny

this, they are but confessing that species are for them descriptions in books, not aggregates of similar individuals in nature. From the biological standpoint there could scarcely be more useless and unproductive labor than this of matching descriptions. The merits of a proposed species, that is, its normal segregation in nature, are not to be inferred from the formal description of a few individuals, and all so-called "species" established on such a basis are merely tentative propositions — suggestions for study. The question is not whether the description is different from all other descriptions, but whether the type specimen is, in reality, a member of an independent series of individuals, a distinct branch of life, a separate island of existence. The systematist is in no way responsible for the conditions; it is his business merely to recognize and record them. The difficulties vary greatly in different parts of nature, depending upon facts in the biology of the various groups. Thus the well-nigh inextricable confusion of the genus *Sphagnum* is undoubtedly connected with the fact that all the species have almost exactly the same position in the economy of nature, and affect the same habitat, while segregation has been further hindered or at least obscured by the absence of any natural period to the life of the individual plants. Remotely ancestral and all succeeding forms may still exist simultaneously and contiguously, affording a rare complication of difficulties. But in this case, as in others, we can best gain knowledge of the lines of divergence and learn something of the present tendencies of evolution by locating the breaks in the series of forms. The use of the term "species" may be a matter of indifference, but confusion in this formal regard should not be allowed to obscure the interest which attaches to the history and status of so isolated a group of plants.

Having once located and delimited our specific islands, the work of studying their internal topography is comparatively simple. The limitation of subspecific groups is necessarily arbitrary, but it need not be on that account artificial, the object of such subdivision being the recognition of tendencies toward segregation, rather than the formation of groups of uniform size. We are concerned, in other words, with the natural

features of our islands rather than with the number of farms or building lots into which they may be subdivided.

The fourth type of species may not appear logically distinct from the second and third, since natural hybrids occur, and have had, no doubt, their influence in evolution. From the practical standpoint, however, it may be maintained that the hybrid nature of a new form is not to be assumed without reason; and it is plain, in addition, that where we know the history and ancestry of a hybrid or selective variety, we should draw every possible advantage from that knowledge instead of undertaking the gratuitous labor of attempting a second and entirely artificial diagnosis. With domestic animals classification is carried to its ultimate extreme by means of carefully recorded pedigrees, while in the cultivated plants a similar refinement exists, particularly in the varieties of fruits which are propagated by grafting, the so-called variety being, in a sense, but a single individual, in spite of its extensive multiplication and distribution. Such classifications are not less scientific because they are also of practical utility, and the necessity of uniformity in the nomenclature of artificial varieties and hybrids is becoming a scientific as well as a popular necessity. At the same time it is extremely doubtful whether the desultory systematic methods of the past and present can supply such a desideratum. Any attempt at instituting an authoritative nomenclature of cultivated plants would need, in justice to the practical interests concerned, to be so equipped as to furnish prompt and accurate determinations, and to be able to incorporate into knowledge and provide names for all new varieties without loss of time. Such a plan once carried into execution would be of the greatest importance to agriculture, since it would render practicable the execution of laws which might be enacted to prevent the present enormous losses from falsely named and dishonestly advertised seeds and propagating stock.

VACATION NOTES.

DOUGLAS HOUGHTON CAMPBELL.

I. Notes on the Californian Flora.

During the past summer my vacation was spent in visiting various parts of the Pacific Coast, my travels extending as far north as Skagway. While it must be admitted that the various trips made were intended primarily for recreation, rather than for scientific purposes, still a botanist could not fail to be deeply interested in the rich and striking flora of our western possessions, and I have tried here to jot down some of the impressions made upon me in my wanderings over this most picturesque part of our country.

It is hardly necessary to remind the botanist how very marked are the differences between the floras of the Atlantic and Pacific regions of the United States, especially in the more southern parts. The topography of the Pacific slope, with the lofty Sierra extending practically without a break from Alaska to Mexico, produces climatic conditions very different from those of the Atlantic States. The differences in climate, together with other factors affecting the origin and distribution of the western plants, have resulted in a flora which makes most of California seem very unfamiliar to the eastern botanist.

The Santa Clara Valley, in which Stanford University is situated, is thoroughly representative of middle California. This is the great fruit region of the state, and the level floor of the valley and lower foothills are largely given up to orchards of prunes, apricots, and peaches, while extensive vineyards are also planted, and large quantities of wine are made in some sections of the valley.

The valley opens at the north upon a long extension of San Francisco Bay, and here the extreme width of the valley is perhaps fifteen miles, narrowing rapidly as we go south. To

the east lies the Mt. Hamilton or inner coast range, with Mt. Hamilton, some 4500 feet above sea level, as its highest point. To the west rise the densely wooded Santa Cruz mountains, somewhat lower than the eastern range, and separating the valley from the ocean.

The floor of the valley and the rolling foothills are covered with spreading oaks, which in places form extensive groves, which can hardly be dignified with the name of forests. The scattered groups of oaks give a park-like aspect to the landscape which is most attractive. The prevailing species are the live oak (*Quercus agrifolia*) and the white oak (*Q. lobata*). Along the water-courses and roadsides there is a dense growth of shrubs, the remains of the "chaparral" or thickets which originally covered much of the valley. The chaparral is composed of a variety of shrubs and small trees, among which may be mentioned the Californian buckeye (*Æsculus californica*), Bigelovia, *Rhamnus californicus*, poison oak (*Rhus diversiloba*), toyon (*Heteromeles arbutifolia*), and elder (*Sambucus glauca*), the latter a very characteristic species with glaucous berries, and forming a small tree of 15 to 20 feet in height.

Along the water-courses and in the moist canyons leading into the valley are various trees, but none of very large size. Besides the species of willows and poplars, alders, becoming trees 50 to 60 feet high, are common; and with these are a number of trees less familiar to the eastern botanist. The beautiful bay tree (*Umbellularia californica*) is abundant, and the equally striking Madrõno (*Arbutus menziesii*), with its smooth cinnamon-red branches and magnolia-like evergreen leaves, is decidedly novel in appearance. The Oregon maple (*Acer macrophyllum*) is also a conspicuous tree of this region. An occasional redwood (*Sequoia sempervirens*) is sometimes found along the banks of the streams several miles away from the base of the mountains, but it is in the sheltered canyons higher up that this monarch of the coast ranges reaches its full development.

The common flowers of the valley are the characteristic ones of the central Californian region, and are, for the most part, of southern origin. Many leguminous plants, especially pecul-

iar species of Trifolium, Lupinus, and Hosackia, abound; and early in the spring the grassy meadows and hillsides are often covered with masses of these flowers as well as many others. Species of Nemophila and Phacelia represent the Hydrophyllaceæ, while the Borraginaceæ include species of Amsinckia and Erytrichium, which, although the flowers are small, occur in immense quantities, and are thus very conspicuous. Unfamiliar Scrophulariaceæ, like Orthocarpus, Mimulus, and Collinsia, and the showy poppies, Eschscholtzia, Mecanopsis, and Platystemon, are all very different from their eastern relatives. Many beautiful liliaceous plants also occur in great profusion. The most striking of these belong to the western genera Calochortus—the beautiful Mariposa lilies—and Brodiæa; while higher up among the redwoods are the more northern genera, Fritillaria, Erythronium, and Trillium. In the open sunny valleys these vividly colored flowers often occur in great masses, and form veritable carpets of bloom that it would be hard to equal anywhere.

Later in the season appear hosts of low-growing Compositæ, and on the barren hillsides we may look for the showy Onagraceæ, so abundant in Pacific North America. Besides the familiar Epilobium and Œnothera, there abound species of Godetia and Clarkia, and late in the summer the scarlet fuchsia-like Zauschneria.

With the cessation of the rains, which may occur any time after the first of April, the flowers mostly disappear, and the hillsides assume their summer dress of golden brown until the autumn rains start the seeds into growth again.

Last year was an exceptionally dry one, and when I left San Francisco, about the first of June, the surrounding country was already dry and dusty, and scarcely a trace of the spring verdure could be seen anywhere.

I had engaged passage for Sitka from Tacoma on June 19, but decided to spend the interval at some point in Northern California, which, except for such glimpses as one can get passing through on the railroad, was a new country to me. My destination was Castle Crag, one of the many charming spots in the beautiful mountain region of the north. It lies about 2000 feet above sea level within twenty miles of the base of

Shasta, the most beautiful, if not the highest, of the mountains of California. The view of the glorious snow-covered peak, over 14,000 feet high, is one never to be forgotten. The great pyramid rises from a vast plain, with nothing to break the long, smooth sweep of the slopes of its symmetrical cone. Seen from Castle Crag, the mountain is peculiarly impressive, and its snowy cone, framed by giant pines, is a sight, once seen, to be remembered for a lifetime.

The general aspect of the country about Castle Crag is very different from that of the more southern valley regions. Here the railroad follows the narrow gorge of the upper Sacramento, and on each side the steep, heavily forested mountains rise, the only level ground being little meadows nestled between the bases of the hills or forming a narrow margin to the streams. The rains had not yet ceased, and the vegetation was in the full luxuriance of early summer — a sharp contrast to the dusty sunburned aspect of the lower valleys.

The magnificent forest here has been carefully protected, and gives one a good idea of the character of the virgin forest of the northern mountains. The prevailing trees are the sugar pine (*Pinus lambertiana*), yellow pine (*P. ponderosa*), white fir (*Abies sp.* ?), and Douglas spruce (*Pseudotsuga douglasii*). In the low ground near the streams the yew (*Taxus brevifolia*) was not uncommon, but this does not, in this region at least, form a tree of any size. Along the streams, and forming an undergrowth in the lower forest region, are numerous deciduous trees and shrubs, most of them northern types, and often nearly related to eastern species.

None of the deciduous trees attain a large size, but further north some of them, like the big-leaved maple (*Acer macrophyllum*) and ash (*Fraxinus oregana*), become valuable timber trees. Alders and willows along the streams, and several oaks, the pretty vine-leaved maple (*Acer circinnatum*), and flowering dogwood, are the commonest constituents of the arborescent undergrowth. With these are mingled many fine flowering shrubs which add much to the beauty of the forest. The dogwood (*Cornus nuttallii*), which is said to be even more beautiful than the eastern species, was nearly past, but to judge from the

remains of the large inflorescences, which much exceed in size those of *C. florida*, this may well be true. By far the most beautiful of the flowering shrubs, at the time of my visit, was the exquisite azalea (*Rhododendron occidentale*), which formed extensive thickets covered with masses of the lovely pink and white fragrant flowers. It is not unlike *R. viscosum*, but is much finer than that species. Calycanthus and Philadelphus were seen along the railroad, but were not noted in the immediate neighborhood. Wild roses were abundant, and the thimbleberry (*Rubus nutkanus*), with its big maple leaves and showy white flowers, was very common, as it is throughout the whole of Pacific North America, from the mountains of middle California to Alaska, and east to Lake Superior, where I remember to have seen it for the first time many years ago.

The abundant moisture of the lower forests and the numerous streams at their bases are favorable to the development of a rich herbaceous flora, among which we find many beautiful flowers. The spring flowers, like the Fritillarias and Erythroniums, and the early violets, were gone, but the early summer flowers were abundant. Most of these belonged to familiar genera, and the species were not infrequently allied to eastern ones. *Dicentra formosa*, much like the eastern *D. eximia*, was very common, and *Aquilegia truncata*, differing but little from *A. canadensis*, was frequent. Carpeting the floor of the forest were two or three species of Asarum, one with beautifully reticulated leaves, and several species of Pyrola, among them the curious *P. aphylla*, were common. Above the thickets of brakes in the low ground, the gay flowers of *Lilium pardalinum* were to be seen, recalling the brighter forms of *L. superbum*.

Orchids, which are rare in California, were represented by several striking species. Two Cypripediums, *C. montanum*, much like a white-lipped *C. pubescens*, and *C. californicum*, with smaller flowers, were met with, but both are rare plants. A Habenaria with inconspicuous flowers, and the very striking and peculiar *Cephalanthera oregana* were the two commonest orchids. The latter was frequent in the shady woods, where its ivory-white stems and flowers, the latter with a touch of yellow on the lip, were very conspicuous.

Everywhere along the streams were clumps of the giant peltate leaves of *Saxifraga peltata*, one of the most striking plants of the Californian mountains.

The natural meadows are a marked feature of this region. The absence of protracted drought permits the growth of perennial grasses and other meadow plants. White and red clover have become naturalized, and various Compositæ, like Rudbeckia and Erigeron, mixed with these, gave the meadows a very familiar aspect, although purple and white Brodiæas and some other western plants were mingled with them.

Perhaps the most interesting plant met with near Castle Crag was the curious Darlingtonia — the Californian pitcher plant, which I saw growing for the first time. It occurs abundantly at several points near Castle Crag, but we found it in greatest perfection on a steep hillside sloping to the Sacramento. There are no peat bogs in this region such as harbor our eastern Sarracenias, but the plants were growing in the boggy ground made by the damming of a little stream which flowed down the hillside into the river. Here in the bed of the brook were growing dense clumps of the tall light-green trumpets of the Darlingtonia. Some of these were quite two feet in height, and their vivid apple-green hoods were extremely conspicuous. Here and there the greenish-yellow Sarracenia-like flowers nodded on tall stalks above the leaves, or were replaced by the oval green seed-vessels. Darlingtonia recalls the tall southern species of Sarracenia like *S. variolaris*, with which it agrees in the presence of the translucent spots in the hood, as well as the form of the pitcher. It is much less like *S. purpurea*, which is its nearest neighbor among the Sarracenias. It would be interesting to know how this curious plant has become stranded high up in the Sierra Nevada, so far away from its eastern relations.

While ferns were numerous in some localities, the number of species was not great, nor were mosses as abundant as might have been expected. Aside from the ubiquitous *Pteris aquilina*, the most noticeable ferns were *Adiantum pedatum* and *Woodwardia radicans*, both of which attain great perfection on the shady hillsides, although neither can be said to be very common.

In the moist thickets and meadows, four species of Equisetum were noted — all, so far as I know, that have yet been noted for the state, except *E. hiemale*, whose occurrence here is doubtful. The two large species of the region of San Francisco, *E. robustum* and *E. maximum*, were abundant, and *E. arvense* and *E. lævigatum*, which are apparently confined to the mountain districts, were not uncommon.

Two points in the neighborhood, the granite crags, from which it takes its name, and Cragview Summit, each about 6000 feet above sea level, are easily reached, and their upper regions, which are much more arid than the lower forest, have a very different flora. As we ascend, the dense undergrowth of deciduous shrubs disappears, and the floor of the forest is but scantily covered with vegetation. On the exposed summits the trees either disappear or are much stunted, although the true timber line is considerably higher in more sheltered situations.

On the dry hill slopes there is the usual growth of chaparral, made up largely of species of Ceanothus, one of which (*C. thyrsiflorus*), was covered with heavy-scented blue flowers, known popularly as "California lilac." The densely matted thorny stems of the Ceanothus make at times an almost impassable thicket. In the higher regions several evergreen shrubs formed part of the chaparral. Of these the most conspicuous were the dwarf chestnut (Castanopsis) and manzanita (Arctostaphylos).

Many beautiful flowers grow in these dry regions. Chief of these is the beautiful white lily (*Lilium washingtonianum*), known locally as the Shasta lily. It is very common, and its straight stem and regular whorls of undulate leaves were seen on all sides rising above the low chaparral. Most of them were in bud, but only a few were seen in flower, as they are not in full bloom before the end of June. This beautiful lily is quite different from any of our eastern species, and the form of the flower, as well as the odor, recall the magnificent Japanese *L. auratum*, although the flowers are very much smaller.

Other showy flowers noted were the scarlet *Delphinium nudicaule*, *Iris macrosiphon*, *Calochortus maweanus*, species of Castilleia, Godetia, Pentstemon, and the curious *Spraguea umbellata*, a characteristic plant of the higher Sierra. *Symphoricarpus sp.?*

and *Smilacina amplexicaulis*, much like *S. racemosa*, were also noticed, and in places, *Veratrum californicum*, with its great plaited leaves, was very conspicuous.

A second trip was made later in the summer to the higher Sierra of central California. My destination was Lake Tahoe, that beautiful mountain lake lying over 6000 feet above the sea, on the boundary between California and Nevada. It lies on the eastern slope of the mountains, and the surrounding country is much more arid than the western slope of the Sierra. The lake is very deep — over 1600 feet in places — and the waters are marvelously clear and of an intense sapphire blue, such as I have never seen elsewhere except in tropical seas. Very little vegetation exists in the lake itself, and only in a few places are the shores at all marshy.

The past summer was an exceptionally dry one, and I must confess to a feeling of disappointment in the flora of the surrounding country, which was nearly everywhere dry and dusty.

Where the shores of the lake have been undisturbed there is a good growth of trees, some of quite large size. Some of the yellow pines were about 150 feet high and five feet in diameter, but the trees do not attain the dimensions of those in the great forest belt on the western slopes of the mountains. In most places the timber has been cut, and the shores present a miserable appearance. Besides the yellow pine, there is some sugar pine and tamarack (*Pinus contorta*, var. *murryana*), and the incense cedar (Libocedrus) and several firs are also not uncommon.

The growing season is very short, and the trees must grow very slowly, to judge from stumps which were examined. This is especially true of the cedars. A stump, perhaps five feet in diameter, showed over 700 growth-rings, and doubtless some of the largest trees were at least 1000 years old. The pines grow much more rapidly, none of the yellow pines examined being over 300 years old.

Among the trees there is little undergrowth, but the exposed places and the hillsides are covered with an impenetrable thicket of Ceanothus, manzanita, and dwarf chestnut, with a sprinkling of other shrubs.

The most beautiful part of the lake is the southern end, where there are extensive meadows and apparently more moisture than in the other parts of the shore. Here also are the highest mountains, rising from 4000 to 5000 feet above the lake. Here were found the only marshes seen about the lake. At one point a small stream enters the lake, flowing through level meadows and forming small marshes in which a number of interesting aquatic plants were observed. These included a number of interesting algæ, as well as Utricularia, Potomogeton, Nuphar, Sparganium, and others not noted elsewhere.

In ordinary years it is said that snow lies on several of the peaks for most of the summer, but last year, in August, there were merely a few small patches on Mt. Tallac, the most accessible of the higher peaks.

My first stopping-place was at "McKinney's," on the west shore of the lake, and from here a number of excursions were made in various directions. The shores of the lake at this point are low, and the forest comes down to the water's edge. As we have already indicated, the forest is composed entirely of Conifers, but along the streams, and in a few places on the hillsides, are small groves of willows, alders, and poplars which, however, are never of large size. The sandy soil between the trees was covered in spots with low-spreading mats of Ceanothus and Arctostaphylos, but was often quite bare. Flowers were scarce, but there were a few showy ones, the most striking being a brilliant blue Pentstemon, scarlet Castilleicas, two or three Gilias with scarlet and flesh-colored flowers, and the big sunflower-like Wyethias.

In the shelter of the denser woods, away from the lake, were other plants which needed more shade. A dwarf form of *Rubus nutkanus* was common, and species of Pyrola and Chimaphila, as well as two orchids, *Goodyera menziesii* and *Corallorhiza sp.?* were found here. At a number of places the withered remains of the curious snow-plant (*Sarcodes sanguinea*) were seen, but its season was past.

At the extreme southern end and on the western shore, the shores become more arid, and the growth of trees is scattering. The open ground and the lower hills are covered with sage-

brush and other plants characteristic of the Nevada deserts, and the vegetation is thus intermediate to some extent between the desert flora of the Great Basin and the mountain flora of the Sierra Nevada.

The higher altitudes show a more or less pronounced alpine flora, which was seen to best advantage when making the ascent of Mt. Tallac, whose summit is nearly 10,000 feet above sea level. At the wind-swept summit the characteristic alpine white pine (*Pinus albicaulis*) at once attracted attention. The gnarled trunk, with smooth light-gray bark, and the twisted branches were beaten flat upon the ground in the more exposed situations. This well-marked species is one of the most striking of the numerous Conifers of the Sierra. A little lower down a juniper — probably *J. occidentalis* — was noticed, a tree of perhaps 30 to 40 feet in height, with massive trunk and branches. In sheltered hollows near the summit, beds of arnica were blooming, and among the flowers were swarms of bees and butterflies which had been attracted to these high altitudes. Of the flowers encountered on the way up, the most striking was a beautiful blue gentian, probably *G. calycosa*. Other plants noted were *Aconitum Fischeri*, a tall blue larkspur (*Delphinium scopulorum ?*), and the heath-like *Bryanthus breweri*, the latter unfortunately past flower, but said to be one of the most beautiful alpine plants of the Sierra.

The Washington lily is very abundant about Lake Tahoe, where it reaches its finest development. Specimens four or five feet high are common, and in favorable seasons it is said that specimens seven feet high, with twenty or thirty flowers on a stem, are sometimes found. The pretty little tiger lily (*L. parvum*) is not at all rare in moist ground, where the stems sometimes carry a dozen or more of their graceful bells.

No attempt has been made in this hasty sketch to give a full list of the plants of the regions visited ; this is obviously impracticable. Such have been selected for illustration as seemed to emphasize the peculiar characters of the districts, and such as would naturally attract the attention of the casual visitor.

No region of equal area in our country offers such great range of conditions as does California, and, as naturally might

be expected, this is reflected in its remarkably rich and interesting flora, which offers a most attractive field to the student of geographical distribution of plants. The state extends over ten degrees of latitude, with a coast line of over 1000 miles, and its highest mountains rise 15,000 feet above sea level. There are regions like the Mojave desert and Death valley which are absolute deserts, while in the northern coast ranges there are points where the annual rainfall probably exceeds 100 inches, and the forests of giant redwoods rival the jungles of the tropics in the rank luxuriance of their vegetation.

The great barrier of the Sierra Nevada and the even temperature of the ocean waters, due to the Japan current, combine to give the whole state a far more equable climate than is found elsewhere in the United States; and in the lowlands, winter, as we know it in the eastern states, does not exist, but instead the year is divided into two sharply marked seasons, the wet and the dry, of approximately equal length in the central part of the state.

Besides these great climatic differences, which have profoundly influenced the native flora, the peculiar topography of California has also been an important factor in determining the origin of many of the plants. Direct communication with the eastern half of the continent is prevented by the great mountain barrier of the Sierra, and the mountains and deserts of the Rocky mountain area. It is only on the north and south that there is free communication with the neighboring regions, and we find, in consequence, a curious mingling of northern and southern plants, with an almost complete absence of peculiarly eastern American types.

The continuous ranges of mountains extending into British Columbia and Alaska offer an easy road for many northern plants, which are equally at home in the coast ranges and Sierra Nevada, and in Canada and Alaska. With the rapid diminution in the rainfall south, most of these finally disappear, and are quite absent from the southern part of the state. Most of these northern genera, *e.g.*, Trillium, Claytonia, Erythronium, and others, are found both in Asia and northeastern America; but there are several Asiatic types which do not reach Atlantic

North America, but are restricted to the Pacific side of the continent. The genus Fritillaria is represented by a number of showy species, one of which extends as far south as San Diego; another striking instance is the western skunk cabbage, Lysichiton, a monotypic plant common to the north Pacific coasts of Asia and America.

In the valleys of the central part of the state and throughout the southern regions the plants are very different from those of the north, and have very little in common with the flora of the eastern states. Mexico and western South America are the regions which are most nearly allied in their flora to this southern district. Most of the characteristic genera of this region are either entirely absent from the Atlantic states, or else represented by very few species. Much of this area is excessively dry, and such plants as the cacti, agaves, yuccas, and other desert types give a very marked character to most of this region.

The central part of the state, especially the region about the bay of San Francisco, is a meeting-ground for the northern and southern floras. In the valleys the flora is largely composed of the southern elements. Such genera as Lupinus, Eschscholtzia, Nemophila, Orthocarpus, Brodiæa, Calochortus, Calandrinia, and other common and showy flowers of the open valleys and foothills, are represented by species either identical with the southern ones or closely allied to them. The flowers of the higher mountains, however, especially those of the moist forests of the outer coast ranges, are largely of northern origin, and these often follow the sheltered canyons down to the level of the valleys, where they mingle with the valley flora.

Probably no feature of our Pacific flora strikes the eastern botanist so forcibly as the preponderance of coniferous trees. From Sitka to San Diego, it is Conifers which give the peculiar stamp to the forests, whether at the timber line on the highest peaks, or battling with the ocean winds along the coast. It is true that in the valleys and on the lower hills groves of oaks, without accompanying Conifers, are met with; these can hardly be said to form forests, and wherever the moisture is sufficient to support a true forest growth, it is the Conifers which are the

prevailing trees. The deciduous trees which accompany them are small in comparison with their gigantic companions, and merely form an undergrowth for these.

Of the sixty or more species of Conifers found on the Pacific Coast, the larger part occur in California, which possesses more species than the whole United States east of the Rocky Mountains. An unusually large number of these are peculiar to the state and of very restricted range. Among the better known of these peculiarly Californian Conifers may be mentioned the two Sequoias, *i.e.*, the redwood and giant Sequoia; *Punis insignis*, and *Cupressus macrocarpa*. The number of endemic angiosperms is also very large.

It is doubtful whether anywhere there are more magnificent forests than the great redwood forests of the coast range or the forest belt of the western slopes of the Sierra Nevada, where grow the great Sequoias in company with noble sugar pines and giant firs and cedars.

In this land of big things nothing has impressed me like these giant trees, the true kings of our American forests.

THE MAINTENANCE OF THE EQUILIBRIUM AS A FUNCTION OF THE CENTRAL NERVOUS SYSTEM.[1]

PROFESSOR HEINRICH OBERSTEINER.

It is difficult for man to exist, more difficult than would be supposed from a superficial consideration. In his earliest childhood man stands—or, better, lies—here in the world and finds before him a series of tasks for which he is but partially fitted. Fortunately, we bring with us into the world a most finely elaborated organism, by which from the beginning a great part of this work is essentially lightened. For example, our hearts beat regularly, we breathe rhythmically, and so forth. For even at birth the mechanism of the circulation and of breathing is so completely developed that these functions can proceed quite independently and without our further assistance. Were we obliged to give our constant attention to these two absolutely necessary functions, where should we find the time for any intellectual labor?

In other fields, however, it is not so easy for us. The child has to practice long before it can sit upright, and still longer before it can stand and walk. But having once thoroughly learned this feat, having made it completely our own, it is no longer necessary — at least under normal conditions — to give our supervision, our conscious assistance, to the equilibration of the body. This is maintained quite unconsciously, while the mind is engaged with other things. We can, for example, follow a process with strict attention while sitting or standing, without becoming upset or falling from the chair — unless perchance we fall asleep.

It is a most wonderful and advantageous physiological ar-

[1] A lecture delivered before the Verein zur Verbreitung naturwissenschaftlicher Kenntnisse in Wien. Translated from the *Schriften des Vereins*, Bd. xxxvii, by Guy M. Winslow, Ph.D.

rangement that just those vital processes which demand the most time, continuing as they do throughout our whole life, need no assistance from our consciousness, but are performed automatically.

It will now be my purpose to show how the preservation of the equilibrium may be accomplished, how we can stand and move without being conscious of the complicated mechanism brought into action, and yet without constantly falling. We shall also take occasion to mention derangements of this mechanism, for right here we shall find many indications which are important for the comprehension of normal conditions.

We begin with the simplest process of standing erect:

> Sehe jeder, wie er's treibe,
> Und wer steht, dass er nicht falle.

What, then, happens when we remain quietly standing erect? In order to do this a great number of our muscles, indeed nearly all the muscles of the trunk and lower extremities, must coöperate. The impulse for this coöperation is transmitted to the muscles from the brain; but in order to stimulate the muscles properly, the brain needs a number of external impressions, sensations, which incite the impulse, and regulate it. We shall then have to inquire how the muscles must coöperate to produce the erect position. We shall endeavor to penetrate farther into the secret of the complicated apparatus of the brain, which works so nicely, and, finally, we shall turn our attention to those sensations which furnish the necessary material for this part of the activity of the brain.

I have mentioned above how great a number of muscles is required simply for standing. It is not necessary, however, that all the muscles concerned should contract; if all our muscles were in a state of strong contraction, making the body stiff and motionless, we should be as unstable as a broomstick which had been placed upright on the floor. It is, rather, necessary that each of these muscles contract with a certain strength, up to a definite point, so that each little inclination of the body be counteracted by a stronger contraction of the opposing muscles, while others are correspondingly relaxed.

There is needed for this a very finely calculated and graduated intensity of action by each of the components of motion, a process which is designated as coördination of the muscles, in this case as static coördination.

Let us again take the stick of wood, which would not remain standing before, and fasten a number of strings to its upper end. Now let us set it up again and pull slightly in different directions, laterally, and a little downwards. Probably it will at first fall over to one side toward the strongest pull, but if we modify the strength with which it is drawn in the different directions, we shall finally cause it to remain quietly standing in a vertical position. A condition of equilibrium has been reached by the proper coördination of the forces acting, the same as occurs with a standing man through the coördination of muscles.

Intentionally I lay special stress upon this unusually important factor of coördination of the muscles, which takes a significant part in each muscular act, even though the result be unsuitable to the purpose which prompts it. Indeed, we may go still farther and say that wherever several factors coöperate for the attainment of a uniform result, a proper determination of the intensity with which each shall act is absolutely necessary. Without going into complex social conditions I may give an illustration from art.

If, in the well-known Seventh Symphony of Beethoven, the bassoonists conceive a desire to play fortissimo in the wrong place, the effect will be destroyed as much as if the contrabass were to play a very light piano in a place written forte. Each player finds certain signs with his notes, the dynamic signs of expression, which show him not what, but how, he ought to play.

The corresponding signs which make known to our brain how each muscle must act for the attainment of static coördination are imparted to it by different sense organs. As the first, though not the most important of these, I mention the touch sensations of the sole of the foot. If we stand, and still more if we walk, we feel the ground beneath our feet. It needs no long reflection to perceive how difficult simply standing

would be for us if our feet were insensible. We can understand this easily, because we are able at any time to bring the sensations of touch and pressure in the sole of the foot before our consciousness.

Far more important, however, are sensations of whose existence many men know absolutely nothing, namely, those from the joints, tendons, and muscles. By the nerves from these organs the brain receives information in regard to their condition, but this takes place in such a way that these sensations do not generally overstep the threshold of consciousness. They serve almost exclusively automatic purposes, and would therefore unduly and uselessly burden our attention. But it is an established fact that we may be conscious of the muscular sense. We are conscious, for example, of the strength, the exertion which is required to lift a weight; indeed, we can estimate the weight of the object lifted by the strength expended, and distinguish the heavier object from the lighter. For this reason the muscular sense has also been called the strength sense. The pains of fatigue, or the strong muscular pains caused by cramps, are perceived by means of the same nerve tracts.

There are many who deny the existence of a muscular sense; for example, Wundt. He prefers to refer whatever is ascribed to this sense to the sensations of the central nervous system. But many facts, especially pathological conditions, incline us to admit a muscular sense.

Having now become acquainted with the existence of the muscular sense, we can comprehend that in this region we must seek the most important sensations which render possible the coördination of the muscles and standing erect.

The great significance which the joints and joint nerves attain in this process as a result of their position is self-evident. But these stimuli, transmitted from the locomotor apparatus, that is, the muscles, joints, tendons, etc., to the central nervous system, may perhaps be utilized in another way for the coördination of the muscles. E. Hering proposes the following: At each slightly energetic movement, for example the bending of the arm, those muscles which produce the opposite movement—the antagonistic muscles, in this case the extensor muscles of

the arm — are relaxed; thus the nerves of these muscles are stimulated, and there results a certain reflex contraction of these opposing muscles. An excess of the intended movement is thus prevented. If this opposition, this restraint, be for any reason lacking, the movement becomes disordered and unsteady, as we indeed see in certain diseases.

Less striking, but yet not to be overlooked, is the rôle which the so-called visceral sensations play in the process under consideration. From all the viscera there are nerves which convey sensations to the spinal cord and the brain; of these sensations also we are, as a rule, unconscious, except when the organ from which they come is diseased. As soon as we become conscious that we have a liver, then the liver is usually diseased. The viscera are suspended freely within the body cavity; each change in the position of the body must then produce a greater or less displacement of the viscera. This displacement is not generally a matter of consciousness, yet an unconscious sensation is transmitted to the brain. It is evident, then, that the visceral sensations are of essential assistance in the preservation of the equilibrium.

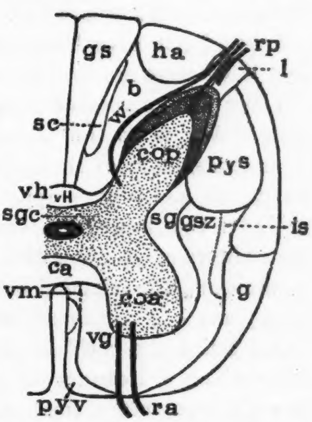

FIG. 1. — Transverse section of spinal cord. *b*, Burduch's column; *ca*, anterior commissure; *coa*, anterior horn of gray matter; *cop*, posterior horn; *g*, Gower's bundle; *gs*, Goll's column; *pys*, lateral pyramid tract; *pyv*, anterior pyramid tract; *ra*, anterior root; *rp*, posterior root of spinal nerve.

It will be in order to introduce here a brief anatomical note. We have thus far spoken of the sense of touch, especially in the soles of the feet, and of sensations from the joints, tendons, muscles, and the viscera. These are all perceived by means of nerves which enter the spinal cord through the posterior roots (Fig. 1, *rp*). If we examine a transverse section of the spinal cord (Fig. 1), we find about its center a reddish-gray mass (*cop* and *coa*), the gray matter, while the remainder of the section is made up of the white matter. This white matter consists

almost exclusively of nerve fibres, which for the most part run longitudinally along the spinal cord. Thus, if we cut the spinal cord transversely, we have a countless number of cross-sections of nerve fibres. But, although even under the microscope the whole field of white matter appears quite homogeneous, we know that it is divided into a number of fibre bundles of varying significance and function. Thus we distinguish in each half section of the spinal cord about sixteen different regions.

The nerves mentioned above, and which are of significance to us, enter the spinal cord through the posterior roots, and take their further course to the brain, perhaps exclusively by way of the posterior bundles (*gs*) and (*b*), the lateral cerebellar tracts (*ks*) and Gower's bundle (*g*).

I would not have bothered you with these dry anatomical data if we were not to need them later.

I turn now to another class of sensations, which likewise are scarcely known to the non-scientific, since they, like the muscular sense, perform their function outside the sphere of consciousness, and become apparent only when they are irritated.

Under this head let us consider the inner ear, that part of the auditory organ which lies deeply buried in the hardest bone of the skull, the temporal bone. We find in this two principal parts; one has the characteristic form of a snail shell, and is hence called the cochlea; the other consists of three curved tubes which are connected in such a way that the two ends of each open into a small sac-like enlargement, the utriculus. These tubes are called the semicircular canals; together with the utriculus they form the labyrinth of the ear. If one imagines a plane passed through each of these three arches, it will be found that the three planes are perpendicular to one another. It is only when the cochlea itself becomes diseased or destroyed that a defect of hearing occurs. This effect is not produced by injuries to the labyrinth. In the latter case, on the other hand, very peculiar disturbances of the equilibrium are experienced. These facts were first demonstrated by Flourens. I cannot here go further into the very interesting investigations which were carried out later, especially by Golz, Breuer, and Ulach, among others, for the determination of the

function of this little organ. Even in the lower forms, for example in the crabs, Kreidl was able to establish the same fact.

The result of this discovery, as well as the observation of diseases of the labyrinth in man, has taught us that this part of the inner ear, that is, the labyrinth, represents a sense organ which gives to the individual information in regard to the position of the head in space. This organ produces the sensation of turning, and thus controls the perception and maintenance of equilibrium. We have, then, acquired a sense of equilibrium, the peripheral sense organ of which is to be found in the labyrinth, and which transmits its sensations to the brain by means of a part of the auditory nerve.

The method of action of this sense organ is as follows: both in the utriculus and at places in the semicircular canals, the ampullæ nerves terminate in cells from which cilia project into the inner lumen; there is also in the utriculus, at the end of these nerves, a cluster of fine crystals — the otoliths. The utriculus and semicircular canals are filled with a fluid, the endolymph, which is agitated by each movement of the head, and which thus bends the cilia. The otoliths contribute to the reënforcement of this stimulation. At the beginning of a turn of the head in the plane of one of the canals, the fluid, as has been shown by Breuer, lags behind, and so strikes in the opposite direction against the cilia.

The task of maintaining the equilibrium is, again, essentially lightened by the sense of sight. This point hardly needs a detailed presentation. The impressions of vision give us information as to any change in the position of our body, and every one knows that we stand or move unsteadily in the dark or with closed eyes. And here I will emphasize the fact that the sensations from the eye muscles are also essential components of the mechanism of equilibration.

Recapitulating, then, we may say that the following sensations coöperate for the equilibration of our bodies: touch sensations, which are perceived by means of nerves from the joints, tendons, and muscles; sensations from the labyrinths; and, finally, optic sensations. All of these sensations are collected

and employed in the brain with such a resulting effect upon our body musculature that the desired object, the preservation of equilibrium, is attained.

We have now to investigate further what part of the brain is intrusted with this important and complicated function.

First, I may again point out that we are, as a rule, entirely unconscious of many of the sensations concerned in this process. And since we are justified in concluding that, in order to become conscious, sensations must pass to the cortex of the cerebrum, we are from the first inclined to look for the organ of equilibration which controls the coördination of the muscles elsewhere than in the cortex of the cerebrum. There is also a series of facts which makes it highly probable that the part of the central apparatus sought is to be found in the cerebellum.

The cerebellum is an organ which is clearly separated from the rest of the central nervous system, and which in its finer structure differs essentially from all other parts of the brain. It has also a special and peculiar function. In comparison with the other parts of the brain it is not proportionately well developed in all animals. In mammals and birds the cerebellum is not only relatively large, but its surface is increased many times by numerous delicate and usually deep parallel furrows. In the Amphibia and many reptiles, on the contrary, it is reduced to a simple small ridge. While the first-mentioned groups require very sensitive and complicated muscular action for the maintenance of the equilibrium while standing, running, and flying, in the other groups a much simpler apparatus suffices for mere crawling or jumping. In the fishes the cerebellum is larger than in the Amphibia, yet with the exception of one of the cartilaginous fishes it is still smooth. Frogs, it is true, swim, but with far less rapidity and precision than fish. Thus we actually find a certain parallelism between the size of the cerebellum and the delicacy of the muscular coördination.

Another anatomical fact is now to be considered. We are acquainted with certain tracts of the spinal cord which we know convey to the brain a part of the sensations necessary for the preservation of the equilibrium. We know that, directly or indirectly, all of these tracts are intimately connected with the

cerebellum, and some of them pass entirely into it. No connections between the nerve fibres arising from the labyrinth and the cerebrum are known, but the labyrinth has many direct and indirect nervous connections with the cerebellum.

It is found, therefore, that, with the exception of the optic nerve, all those sensory tracts which are used in equilibration collect in the cerebellum. And there certainly are connectives between the optic nerve and the cerebellum, yet in regard to this our knowledge is very incomplete. These are the purely anatomical considerations which point to the cerebellum as the center of coördination or equilibration. But physiological experiment also shows us facts which lead to the same conclusion.

Only a carefully performed and rightly interpreted experiment can inform us as to the function of this part of the brain. Erroneous observations and interpretations have ascribed to the cerebellum all possible functions; for example, the seat of the soul, the emotions, the memory, and so forth.

If one wound the cerebellum of an animal badly, or if he extirpate a portion of it, there is no proper regulation of the muscular contractions, and there is a decided disturbance of the equilibrium, resulting from the defective innervation of the muscles. An animal thus treated makes the most senseless and inopportune motions without accomplishing its purpose; yet it hears and sees, and its intelligence appears not to be interfered with.

Similar phenomena occur in men having diseases of the cerebellum. As we shall return to this point again, I will here only briefly note that, in most cases of serious disease of the cerebellum, disturbances of the equilibrium and dizziness are present.

We have found, to summarize the above, not absolutely certain proof, but still a number of important reasons which fully justify us in searching in the cerebellum for the central apparatus for muscular coördination, and the resulting preservation of equilibrium.

Thus we have solved a part of the problem presented to us. We can now represent diagrammatically (Fig. 2) the whole apparatus which must take part in the process of equilibration. To the cerebellum (*k*) there are transmitted various sensations

coming from the skin (*hs*), the muscles and joints (*ms*), the viscera (*vs*), the labyrinth (*l*), and from the eyes (*a*). All these sensations are combined in the cerebellum into a single resultant nervous impulse which influences or modifies the movements incited by the cerebrum in such a way that the coördinated effect desired is attained; so that the different muscles *m* and *m* contract in the proper manner. This may be stated somewhat as follows: The cerebellum does not — on the basis of the sensations conveyed to it — apportion the necessary stimuli to the muscles concerned in an action separately, but distributes it as a whole to the muscles concerned.

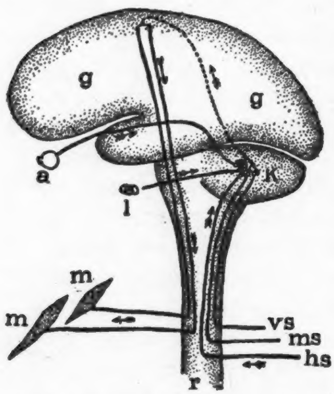

FIG. 2. — Diagram of nerve tracts employed in coördination for maintenance of the equilibrium. The arrows indicate the directions of the nervous impulses. *a*, eye; *g*, cerebrum; *k*, cerebellum; *l*, labyrinth; *hs*, *ms*, *vs*, nerves for impulses from skin, muscles, and viscera; *m*, muscles.

In the above diagram we may consider the relations of certain sensory nerves to the cerebellum, as well as to the tracts which receive their impulses from the cerebellum and transfer them to the muscles, to be definitely made out. But it is still a question where the cerebellum exerts its regulatory influence upon our movements; where we have to suppose the connection, here represented by a dotted line, is really to be found. But there are also many other gaps in our knowledge of our central nervous system; and for the object at present under consideration this question seems not to be of essential significance.

It is now to be investigated how this coördinating apparatus may act under different circumstances. The simplest task is that with which we have started out, namely, the maintenance of static coördination, that is, the preservation of equilibrium while standing erect under perfectly normal conditions.

If any one attempts to stand erect and perfectly motionless, he finds that he is unable to do so. A smoked plate has been

placed horizontally above a person trying this experiment in such a way that a point projecting from the cap touched upon the plate. Each movement of the head is then registered upon the smoked plate, and an irregular zigzag line is obtained as the expression of the oscillations of the body. The sway from side to side amounts to one and one-half centimeters; that from before backwards, to two centimeters. The oscillations increase with fatigue and become sensibly greater if the experimenter closes his eyes, or if any other of the factors concerned in the process of equilibration is eliminated. And the oscillations become yet greater in certain diseases, accompanied by the destruction of coördination. We learn from this experiment that it is not possible for us to stand perfectly quiet, but that we are always balancing ourselves within certain limits. By this process certain muscles are brought much into use, and after a time they become greatly fatigued. Then we change our position a little, so as to bring other muscles into play, and at least in part to relieve those exerted earlier. We also learn from these experiments that it is more difficult to maintain our equilibrium while standing if any of the sensations usually participating in the process are inactive. Closing the eyes results in greater oscillations, and anesthesia of the soles of the feet, as I have already remarked, essentially increases the difficulty of standing. The result of a loss of the muscular sensations, or of the sensations from the labyrinth, would be still more serious, while the greatest disturbance of all occurs when several of the component sensations are simultaneously wanting, especially if, as the result of disease, they deceive us by false sensations.

A healthy man under normal conditions maintains his balance while standing in spite of the above-mentioned oscillations, and he is quite unconscious of this process and the attendant difficulties. But if any essential factor of the apparatus for keeping his balance be eliminated or altered in its action, he feels the difficulty of performing the task properly, a feeling which we designate as dizziness. Dizziness is the sensation of the loss of equilibrium combined with the feeling of difficulty in counteracting this loss. As will be easily understood, fear is often associated with dizziness.

We shall, then, find quite different causes for the occurrence of dizziness, according to the part of the balancing mechanism which has its functions destroyed. But first I must briefly mention a peculiar kind of dizziness which is not preceded by any injury to the nervous system, namely, physical dizziness.

We must constantly remember that the process of equilibration usually takes place unconsciously. But if we find ourselves upon a narrow plank lying across a brook, or on the edge of a precipice, we become conscious not only that we have a certain difficulty to overcome in order not to fall, but also that such a fall would be attended by very serious results to us. We attempt, therefore, by voluntarily exerting all our muscles, by extending the arms, and in other ways, to render the process of keeping our balance easier. But in reality we aggravate the difficulty and perhaps finally fall. Fear makes us especially clumsy. It is as if one were riding a beast of burden along a narrow mountain path. As is well known, in such a case one should give himself over to the animal, which is accustomed to travel safely; but if the rider becomes afraid, and tries to guide the animal with the reins, it may easily happen that both perish together. In this figure the animal represents our unconscious coördination, which we destroy when we try consciously to assist it.

If we return now to our diagram, it will essentially aid us in our study of the different kinds of dizziness.

We will begin with the different varieties of sensation which participate in the maintenance of the equilibrium. In the disease of the spinal cord known as tabes dorsalis the posterior roots are first affected. The sensations from the muscles, tendons, and joints then become reduced or arrested. I notice that occasionally the tactile sensations of the skin do not suffer until late, or perhaps not at all; while, on the other hand, the destruction of the visceral sensations is not rare.

As a consequence of the loss of the muscular sense, a man afflicted with this disease shows peculiar symptoms. His motions are not regular, not properly gauged: in walking his feet go shuffling and bumping along, while if he sits they will cross; again, one foot is lifted much too high in the air, though

at the same time he may not be able to send sufficient stimulus to his muscles to produce the contractions necessary for his purpose. This defect in the control of the muscular innervation is called ataxia, and since it is dependent on a disease of the spinal cord it is known as spinal ataxia.

This disease offers yet another phenomenon. During its first stages the patient is generally able to stand quite firmly, even though his feet be placed near together, thus reducing his stability as much as possible. But no sooner does he close his eyes than he begins to totter and become dizzy, finally falling, unless he is supported. The explanation of this phenomenon, known as Romberg's symptom (static ataxia), is to be found in the fact that in closing the eyes the control of the equilibrium dependent on them, a very important factor, is lost.

There is a particular kind of dizziness, called optical dizziness, which depends upon a derangement of the nerves of the eye muscles. Let us imagine that our eyes move without our being conscious of it. It will seem to us that the objects about us have changed their positions in relation to our body ; and since walls, trees, and pieces of furniture, which we know to be fixed, appear in a different direction, we conclude that our body has moved. This erroneous impression passes to the center of coördination, and is answered by a compensating movement of the body, which is naturally unsuitable; then we again feel a loss of balance. Thus is explained the uncertainty in standing and walking which is observed as resulting from many kinds of disturbances in the movement of the eye.

That dizziness also arises from the digestive organs, by means of the visceral sensations, is a fact well known to the laity. But the process here taking place is in no way clear to us.

The phenomena of dizziness and loss of balance, which have their origin in the ear labyrinth, the special organ of equilibration, are of particular interest. Here also we must distinguish whether we have to do with false sensations which are transmitted from this sense organ to the brain, or whether this kind of sensations is entirely lacking.

It is plain to see that the latter condition might easily be followed by less serious results than the former; for if the

sensations from the labyrinth are lost, a more or less complete compensation may be made by the other senses. But the central nervous system will be led into error by false impressions from this organ, and thus be perplexed, even though the control of the other senses remains intact.

I will now call attention to the familiar phenomenon of whirling dizziness, which is produced when we turn swiftly about the long axis of our body. We have seen that the nerves terminating in the labyrinth are stimulated by the flow of the liquid contained in it — the endolymph. But after turning rapidly this fluid does not immediately come to rest, as we see when a vessel containing water is rapidly rotated and then suddenly stopped. By this continued movement of the endolymph the nerve ends are stimulated for a time after the body has entirely ceased to move. False sensations are thus produced which give us a wrong impression of the actual movement of our body and cause dizziness — the whirling dizziness.

The same effect is obtained in whatever direction the turning takes place. From quick movements upward or downward, also, similar results occur. In America, where very tall buildings are now constructed, the use of elevators is frequently attended with dizziness, by which elevator boys are particularly affected.

Seasickness can also be traced, at least in part, to similar conditions. But I will here observe that the viscera also, though in a much less degree, may participate in the production of whirling dizziness and seasickness. If the head be held still, and quick rotating motions be made with the trunk, by which the freely suspended viscera are set in motion, a slight dizziness is often felt.

A peculiar pathological phenomenon, known as Menière's disease, or better as Menière's symptom complex, here deserves special mention. This malady is characterized by dizziness and a buzzing and snapping noise in the ears. One concludes, with much reason, that in such a case the ear labyrinth is directly or indirectly injured. In some cases of this kind, bleedings have been found in the semicircular canals, and fissures in the temporal and other bones.

A complete absence of the sense of equilibrium is found in a

number of deaf-mutes, in about fifty-six per cent of whom the ear labyrinth is entirely degenerated. Such deaf-mutes go tottering and stumbling along with their legs spread far apart; if, while in the water, they become submerged, they lose their orientation in space. But, as can be easily understood, and as has been demonstrated by Kreidl, they are free from whirling dizziness; likewise (according to the investigations of Pollak) they are immune from galvanic dizziness, which is produced in a normal individual when a galvanic current is passed through the head.

We have seen that through the abnormal or arrested activity of a number of sensory nerves, disturbances of equilibrium and dizziness are produced; we must now go farther and investigate the action of the central nervous system in this relation.

We here pass to so wide a field of observation, however, that I must limit myself to indicating only the rudest outlines.

The cerebellum has been recognized as the most important central organ of equilibration. Severe diseases of the cerebellum are therefore characterized by dizziness and loss of equilibrium. The gait of one thus diseased is peculiarly unsteady, best compared to that of a drunken man. In this case also irregular motions result, but still they are quite different from those I have described for tabes. This kind of defective motion is called cerebellar ataxia.

But a glance at our diagram shows that another part of the central nervous system plays a rôle in keeping the balance. We are next to consider that nerve tract by means of which the cerebellum exerts its regulatory influence upon the tract controlling motion.

In the diagram (Fig. 2) I have indicated this tract by a dotted line, in order thus to express the fact that its course is not perfectly known to us. But notwithstanding this somewhat unsatisfactory condition of our knowledge, we must expect that similar phenomena can be produced from different places in the brain.

Dizziness with severe disturbances of the equilibrium may occur, the brain parts concerned being severely diseased. It is sufficient for them to experience a changed or imperfect

nutrition. This occurs, for example, with a general loss of blood, anæmia, or when the loss of blood affects the brain alone; in cases of this kind the symptom increases when the body is quickly raised to an upright position, and decreases when it is placed horizontally.

In a similar manner the nourishment of the brain is interfered with by certain poisonous substances, many of which, such as tobacco and alcohol, especially affect the balancing apparatus. The dizziness and unsteady motions resulting from nicotine poisoning are well known, and yet more familiar are the staggering movements following too free indulgence in alcoholic drinks. From the great similarity which exists between these symptoms and those of cerebellar ataxia, one may perhaps reasonably conclude that the effects of alcohol are more detrimental to the processes of nourishment in the cerebellum than to those in other parts of the brain.

Finally, mention should be made of numerous other circumstances which may interfere with the circulation in the brain, and by which, again, dizziness may be caused. Here belong, for example, epileptic dizziness, the feelings of dizziness which are often observed at the beginning of acute contagious diseases, and many other cases.

According to the plan which we have thus far been following, those derangements of equilibrium which originate in the locomotor apparatus should now be considered. Here the conditions are essentially simpler. If a muscle which is of importance in standing, or a whole group of such muscles, become paralyzed, the patient is no longer able to stand erect. Even a partial paralysis of such muscles will be sufficient to render standing, without external support, impossible. The result is exactly the same in whatever part of the locomotor apparatus the cause of this paralysis lies; be it in the muscles, nerves, in the spinal cord, or in the brain.

My purpose was to show you in the merest outlines how we are enabled through our central nervous system to maintain our equilibrium. But I have also had a subordinate aim; I wished to illustrate to you by an example the method by which

we arrive at conclusions in regard to such questions. You have seen how we have laboriously to collect the material from different sources; not only anatomy and experimental physiology are studied, but we must add to this a knowledge of pathological conditions. And this latter furnishes us with particularly important and instructive facts; therefore I have allowed myself to devote considerable attention to the pathological disturbances of equilibrium.

Finally, I wished to show you by this example how great a part of the functions carried on by our organism is performed entirely apart from consciousness. Our conscious activity is thus released from what would otherwise be a very considerable burden.

If, then, as I stated at the beginning of my analysis, it is difficult for man to exist, yet we should be thankful to Nature that a great part of the labor imposed upon us is made essentially easier by the organization of our central nervous system, and that time is thus given us to engage in higher intellectual pursuits.

Let us thankfully recognize the value of this gift.

EDITORIAL COMMENT.

Annales du Musée du Congo. — The Congo Free State, one of the last born of the nations, is demonstrating its right to a place in civilization by the publication of a series of monographs on its natural history. These are issued by the order of the Secretary of State as *Annales du Musée du Congo.* Four articles, or fascicles, have appeared — two "Illustrations de la Flore du Congo," by Wildemann and Durand, and two "Matériaux pour la Faune du Congo," by G. A. Boulenger. These last, by the able ichthyologist of the British Museum, treat of the fishes of the Congo, numerous new species being described with excellent figures. The Free State is to be congratulated on its early attention to its local natural history, as well as on the wise choice of the hands in which its material is placed.

A Botanical Calendar. — Under the editorship of P. Sydow the first number of the *Deutscher Botaniker-Kalender* has made its appearance — a little book of 198 pages of text and many pages of advertisements of botanical interest. The first 108 pages are devoted to the calendar proper, there being one page for each week, with the dates of the birth and death of distinguished botanists. It is noteworthy that there are only twenty-two days in the year without such data, and on some days there are as many as four entries. The calendar is printed on one side of the page only, leaving the opposite side for notes and memoranda, for which there is also room under each day. The contents of the book includes the usual tables of coinage, weights and measures, and postal regulations; the rules of botanical nomenclature of the Royal Botanical Garden at Berlin; a list of the cryptogamic exsiccata, systematically arranged; a list of botanical gardens, geographically arranged; a similar list of botanical and natural history museums; and, finally, an alphabetical list of the collections in botanical museums and herbaria. The omissions and inaccuracies usual to the first edition of a book of this character are painfully in evidence as regards American botanical matters. The value of the work would be much enhanced if it included the *personnel* of the different botanical institutions given, and also a botanical directory. We cannot, however, but praise this effort of Dr. Sydow,

and are glad to know that there is so much room for improvement. We wish the *Kalender* every success, and hope to see it a permanent institution, and call upon American botanists to see that our botanical institutions are fully and correctly represented in the edition for 1900. The book is published by the Borntraegers at Berlin for three marks.

The Beiträge zur Biologie der Pflanzen, published at irregular intervals under the editorial care of the late Professor Cohn, of Breslau, has been recommenced with Dr. Brefeld as editor. While the retention of the original title is entirely commendable, it is to be regretted that the new volume should be issued as "Herausgegeben von Dr. Ferdinand Cohn." A change in expression, similar to that made on the title-page of the *Jahrbücher für wissenschaftlichen Botanik* after Professor Pringsheim's death, would better have expressed the facts, while securing the desirable perpetuation of Professor Cohn's name in connection with the journal.

"Natural Science," with the initial number of Vol. XIV, the first under the new management, makes its appearance in a new dress. The greenish tint of the cover has given way to a grayer tone, and the typography of the title-page is somewhat changed. The journal is now printed on heavier calendered paper, and is, on the whole, improved in appearance. The general makeup is unchanged, except for the addition of the new column of "Fresh Facts," which comprises brief references to facts of interest in current literature. We wish our esteemed contemporary a most prosperous and happy new year.

REVIEWS OF RECENT LITERATURE.

ANTHROPOLOGY.

African Skulls.[1]— F. Shrubsall has had exceptional opportunities to study African crania, and has produced a model paper describing the skulls of the Bantus of South Africa. The large number of crania in the series, some two hundred, has enabled him to fairly revel in seriations and averages. How great a satisfaction it is to the craniologist to gain access to a large series is known only to those who have dealt with small numbers of specimens, "too few to furnish satisfactory conclusions," or "too fragmentary for definite results." On the other hand, the study of such a collection involves an immense amount of labor, some idea of which may be gained from the number of measurements recorded in the accompanying tables, which, by the way, appear to better advantage in the enlarged *Journal of the Anthropological Institute* than in the former demi-octavo size. The metrical method is followed in the paper, and the text suffices merely to interpret the figures. This we believe to be the most satisfactory method, though it must be admitted that the descriptions of the "impressionist school" of craniologists have a certain value.

Mr. Shrubsall concludes that the most striking feature of the A-bantu crania is that they are remarkably uniform from all parts of the area under consideration. In the south the skulls show marks of intermixture with the Bushman-Hottentot race. In the east the cranium is also modified, and the question of mixture with Semito-Hamitic peoples is raised. In the northwest the presence of negroid characters indicates crossing with the negroes from the region north of the Congo. Finally, "the obvious affinities" of the Bantus "are with the Monbuttu of Niam-Niam, and the peoples of the Zeriba country, and the Welle-Nile divide." These conclusions are in accordance with the teachings of history and philology. F. R.

Ceremonial Stones. — In the *Proceedings of the Linnæan Society of New South Wales* for December, 1898, Mr. Walter R. Harper

[1] Shrubsall, F. A Study of A-bantu Skulls and Crania, *Jour. Anthrop. Ins.*, N. S., vol. i, Nos. 1, 2, pp. 55–103.

gives "a description of certain objects of unknown significance, formerly used by some New South Wales tribes." These objects are cigar-shaped, of stone or clay, attaining a maximum length of fifty-five centimeters. A number of theories have been advanced to account for their use, but they have not yet been satisfactorily identified. They are decorated with a number of "broad-arrows" and parallel gashes. The seven plates which accompany the article show that these markings are of a rude character, and that considerable variation exists in form and decoration. Mr. Harper brings forward no decisive evidence to account for their use, but concludes with the statement that they are either "pounders" or "ceremonial stones." The latter is a convenient scrap-basket in archæology, and as Mr. Harper does not prove them to be pounders, it might be well to classify them as ceremonial stones; at all events, they are well described and figured in this paper, and others may be able to answer the question raised.

F. R.

ZOÖLOGY.

Adriatic Sponges.[1] — Dr. von Lendenfeld continues in this monograph his exhaustive description of the Adriatic sponges begun in 1891.[2] Like the earlier works of the series, this is divided into three parts. The first part contains a complete list of the literature on the group; the second, a description of the Adriatic species; the third, a comprehensive review of the structure and classification of the Clavulina in general.

The classification adopted by von Lendenfeld in this series of memoirs is as follows:

- Porifera
  - Class Calcarea
  - Class Silicea
    - Subclass Triaxonia
      - Order Hexactinellida
      - Order Hexaceratina

[1] Von Lendenfeld, R. Die Clavulina der Adria, *Abhandl. Kais. Leopold. Carol. Deut. Akad. Naturf.*, Bd. lxix (1898), 12 Taf., p. 251, Halle.

[2] Die Spongien der Adria, Die Kalkschwämme, *Zeit. f. wiss. Zool.*, Bd. liii (1891); Die Hexaceratina, *Ibid.*, Bd. liv (1894); Die Tetractinelliden der Adria, *Denkschr. Kais. Akad. Wiss. Wien* (math.-naturw. Classe), Bd. lxi (1894).

Subclass Tetraxonia
- Order Tetraxonida
  - Suborder Tetractinellida
  - Suborder Lithistida
- Order Monaxonida
  - Suborder Clavulina
  - Suborder Cornacuspongiæ.

Von Lendenfeld defines the Clavulina as marine Monaxonida, possessing as a rule a skeleton made up of rhabdus-like, mostly monactinal, megascleres, arranged for the most part radially to the surface in bundles, and not forming a network in the interior. Occasionally without a supporting skeleton. Mostly without, or with very little spongin. Occasionally with well-developed spongin skeleton. Microscleres, when present, always asters or microrhabdi, never chelæ, sigmas, or toxas. If a well-developed spongin skeleton is present, microscleres of aster or rhabdus type are always found.

This suborder is divided into three tribes: (1) Euastrosa, with euasters, or, if none, then without skeleton. Other microscleres may occur with euasters. Occasionally with spongin. (2) Spirastrosa, without euasters, but with spirasters or other microscleres. Occasionally with spongin. (3) Anastrosa, without microscleres.

In the suborder are included 26 genera, distributed in 10 families. Ridley and Dendy (*Chal. Rep.* on Monaxonida) divide the group into 2 families with 10 genera. Vosmaer (Bronn's *Klass. and Ord.*) makes 2 families with 10 genera, and an Anhang, consisting of 9 genera (chiefly Gray's) of boring sponges, which he provisionally accepts and unites under the family name of Clionidæ. Von Lendenfeld's group owes its size partly to its more comprehensive character, partly to the separation of certain genera from the Clavuline families as recognized by Vosmaer, Ridley and Dendy, such genera being reincorporated as distinct families.

The following brief review of the ten families included in the Clavulina will make plain the scope of the group as defined by von Lendenfeld. In the Tethyadæ are included, along with the type genus and Tethyorrhaphis Lend., a boring sponge (Xenospongia aspis), and Sollas's two genera, Asteropus and Coppatias (united by von Lendenfeld as Asteropus), reckoned by Sollas as among the Tetractinellida. The two genera, Chondrilla and Chondrosia, included by Vosmaer along with Oscarella in his Oligosilicina, are here separated from the latter genus and placed in distinct families, Chondrillidæ and Chondrosidæ (Oscarella by von Lendenfeld is assigned to the Tetractinellida). The family Stelligeridæ is made to include two

genera withdrawn from the Axinellidæ, a family regarded (Ridley and Dendy, *Chal. Rep.*, p. lxii) as transitional between the Halichondrina and Clavulina. These two are Stelligera Gray (Raspailia Vosmaer, 1887) and Hemiastrella Carter (Epallax Sollas, 1887). The above four families constitute the Euastrosa.

The family Placospongidæ includes Placospongia Gray, placed by Sollas among the Tetractinellida. The family Dendropsidæ includes Ridley and Dendy's genus Dendropsis withdrawn from the Axinellidæ. Instead of uniting them in a single family (Spirastrellidæ), after the manner of Ridley and Dendy, von Lendenfeld separates the two genera Spirastrella and Latrunculia, creating the family Latrunculidæ for the latter. Under the family name of Spirastrellidæ he groups with Spirastrella two genera (Vioa Nardo and Thoasa Hancock) of boring sponges; two genera, Ficulina Gray and Halicnemia Bwk., included by Vosmaer and by Ridley and Dendy, under generic names Stylocordyla and Polymastia, in the Suberitidæ; and Alectona Carter, including forms widely separated by Sollas under generic names Scolopes (fam. Scolopidæ close to Suberitidæ, Sollas) and Amphius (included by Sollas as a Tetractinellid in fam. Epipolasidæ). The above four families constitute the Spirastrosa.

Under the Suberitidæ von Lendenfeld groups five genera (Papillella, Polymastia, Tentorium, Trichostemma, Suberites), included by Vosmaer either in the Polymastidæ or Suberitidæ, and by Ridley and Dendy in the Suberitidæ; and two others, Sollasella Lendf. and Suberanthus n.g. The family Stylocordylidæ is erected by von Lendenfeld for a new genus Astromimus, together with Stylocordyla Thomson, which he withdraws from the Suberitidæ, where it is placed by Vosmaer and by Ridley and Dendy. The Suberitidæ and Stylocordylidæ make up the Anastrosa.

Von Lendenfeld gives a statement of the phylogenetic views which underlie the classification he proposes. Suberites, Spirastrella, Tethya have been the productive genera. They with Asteropus have been independently derived from Tethyorrhaphis. From Tethya have been derived, directly or indirectly, Xenospongia, the Chondrillidæ, Chondrosidæ, and Stelligeridæ. From Spirastrella have been derived the Placospongidæ, Latrunculidæ, Dendropsidæ, also directly or indirectly the other genera of the Spirastrellidæ, and the Anastrose genus Papillella (Suberitidæ). From Suberites have been derived directly, or indirectly, the other genera of Suberitidæ (except Papillella), and the Stylocordylidæ.

The Anastrosa (more particularly Suberitidæ) are thus conceived

of as having had a polyphyletic origin, in part (Papillella) from the Spirastrosa, though chiefly from the Euastrosa (Suberites derived from Tethyorrhaphis). Since von Lendenfeld regards (p. 210) Tethyorrhaphis as the "Grundform aller Clavulina," he evidently does not take very seriously the idea (p. 206) that the Euastrosa and Spirastrosa have been independently evolved from different Tetractinellid families — though in the paragraph referred to he apparently countenances this belief.

Of von Lendenfeld's ten families, all but the Latrunculidæ and Dendropsidæ are represented in the Adriatic. Of his twenty-six genera, fifteen, represented by thirty species, are here found. Seven new species (*Asteropus incrustans, Stelligera nux, Placospongia graeffei, Vioa topsentii, Vioa ramosa, Suberites gracilis, Astromimus luteus*) are described, and of the twenty-three already described species, seven for the first time have been found in the Adriatic.

In the descriptive part of the work will be found details of interest concerning the histology and skeleton, together with observations in many cases on the appearance and behavior of the living sponge.

H. V. Wilson.

Revised Classification of the Unionidæ. — Students of the Unionidæ will welcome the revision in the arrangement of the species of this group, which Mr. C. T. Simpson has introduced in Mr. C. F. Baker's report [1] on the Mollusca of the "Chicago area." Anatomical features — other than those of the shell simply — are made the basis for the revision, the structure of the marsupia, for example, being employed as a diagnostic character. The genus *Margaritana* is rejected, *Unio* and *Anodonta* are broken up, the old genera *Alasmodonta, Strophitus, Quadrula, Obliquaria, Plagiola*, and *Lampsilis* are revived, and a new genus, *Anodontoides*, is erected, to provide for the new and more natural grouping of the species. The shell of each of the fifty forms is described at length, and in most instances the external anatomy of the animal is also given. The local distribution is tabulated, and the geographical and geological range of each species is reported. Excavations about the city have revealed as fossils many of the species now reported as living in this area. Measurements are given, and data upon variation, habitat, and breeding are quite extensive. It is to be regretted that the introductory discussion of the group is not phrased in the terms of modern morphology, that

[1] Baker, F. C. The Mollusca of the Chicago Area, Pt. I, The Pelecypoda, *Bull. No. III, Nat. Hist. Surv. Chicago Acad. Sci.* (1898). 130 pp., 27 plates.

the anatomical descriptions are in some cases omitted or incomplete, that the keys were not in all cases revised to meet the new classification, and that the limits of Mr. Simpson's contributions were not more definitely marked. We also note that *Atax*, the common Hydrachnid parasite of the clam, is incorrectly reported as *Diplodontus*. The plates — half-tones from photographs of the shells — afford abundant illustrations, and are in some cases excellent, though they at times fail to reveal important details of structure, such as the beaks and the hinge teeth. The full descriptions, the abundant illustrations, and the keys make the work a valuable handbook for American collectors and students of fresh-water Pelecypoda. C. A. K.

Rotifera and Protozoa of the Illinois River. — The local and seasonal distribution of ninety-three Protozoa and one hundred and eight Rotifera is given by Mr. Hempel[1] as a result of his examination of towings made during 1894 and 1895 in the Illinois River and its adjacent waters. The results reported afford further data indicative of the cosmopolitan distribution of these groups, and the similarity of the pelagic fauna of the fresh water of Europe and America. Some species occur throughout the whole year, or a greater part of it, while others recur only at stated seasons; some reach a maximum in the spring, others in the summer, and still others in the fall, while some reach this condition only in the winter, breeding abundantly under the ice. The predominance of the Brachionidæ among the Rotifera is noticeable. One new species, *Difflugia fragosa*, is described.

C. A. K.

Diurnal Migration of the Plankton.[2] — A single series of observations on the quantity of plankton at certain levels in Lake Leman, by Dr. H. Blanc, suggests a considerable vertical movement, especially of the Entomostraca, toward the surface during the night. Catches were made at the surface, and at depths of 20, 40, and 60 meters in water 100 meters deep. The volume of the catch from surface water at 4 A.M. was 25 times as great as it was at 4 P.M. A large increase also occurred in the catch at the 20-meter level, while at 40 and 60 meters there was no considerable change. The afternoon catch at

[1] Hempel, A. A List of the Protozoa and Rotifera found in the Illinois River and Adjacent Lakes at Havana, Ill., *Bull. Ill. State Lab. Nat. Hist.*, vol. v (1898), pp. 301–388.

[2] Blanc, H. Le Plankton nocturne du lac Leman, *Bull. Soc. Vand. Sci. Nat.*, vol. xxxiv (1898), pp. 225–230, Pl. II.

the surface contained few Entomostraca, but these increased at this level during the night, the Copepoda appearing before the Cladocera, the maximum being attained at 4 A.M. The night catches at the surface and at 20 meters contained great numbers of Ceratium in division. Migration, reproduction, and growth are all factors in this increase in the nocturnal plankton in the superficial layers. No report is made upon the total vertical content of the water, and the data do not afford any clue to the extent of the migration suggested. The position of the thermocline is not indicated.

C. A. K.

Plankton of the Oder.[1] — This potamoplankton is characterized by Schröder as variable, being at a minimum during the winter when the stream is frozen, and in March when it is at flood and full of silt. It attains a maximum during a period of low water in the latter part of the summer. The plankton of the main current is less abundant than that of contiguous bays or of adjacent ponds supplied by the river. It is suggested that the plankton content of flowing water is inversely proportional to the fall of the stream. At all times the phytoplankton of the Oder is relatively small, and is largely composed of diatoms. In the shallower and warmer water of the ponds the Bacillariaceæ are replaced by the Chlorophyceæ and Phytomastigophora. Thus, in general, the diatoms thrive best in cooler water, as in mountain lakes and cold streams, while shade and access of running water favor their development in ponds. In the plankton of the Atlantic Ocean, also, the diatoms predominate in the arctic waters, and are replaced by the Peridinidæ and Schizophyceæ in warmer regions.

C. A. K.

Notes on Nematode Parasites. — 1. It is not often that one is called upon to record valuable contributions to zoölogical literature from the pen of a botanist, but the recently published work of Stone and Smith[2] on nematodes is deserving of more than passing notice. The root-galls produced by certain species of this group are the cause of considerable damage among cultivated plants, and the authors, who were drawn to investigate the subject by reason of its economic importance and bearing on their own department, have given it

[1] Schröder, B. Planktologische Mitteilungen, *Biol. Centralb.*, Bd. xviii (1898), pp. 525–535.

[2] Stone, Geo. E., and Smith, Ralph E. Nematode Worms, *Division of Botany, Bull. No. 55, Hatch Experiment Station Mass. Agr. College* (November, 1898). 67 pp., 12 plates.

a very complete study. From the large amount of valuable matter a few points of especial interest may be selected.

After discussing the economic importance of the question, the structure of nematode worms and the symptoms of their attack, there follows a careful description of the root-gall, in which it is shown that the worms affect the plants, not directly by extracting nutriment, but indirectly by modifying the structure of the root so that the flow of sap is interfered with, and secondarily by weakening it so that it is more susceptible to other diseases. The structure and development of *Heterodera*, the gall nematode, are fully described; and in connection with a careful review of the literature the authors maintain the identity of the German species with that found by Cobb in Australia, that studied by Neal and Atkinson in the southern United States, and that on which they worked themselves in Massachusetts. Although carefully reached, the conclusion is still open to question. The nematodes display great uniformity in general structure, and species are at best often very difficult to distinguish. It is not clear that the lips, together with the oral and caudal papillæ, were examined in all these forms; but these are the characters at present accepted as the most reliable for specific determination. And while specimens of the German form were compared with the Massachusetts variety, it was only the female, while on the analogy of other species in this group the male alone would suffice for specific determination. Furthermore, in some points at least, the habits of the two forms are not in agreement, so that the specific identity can hardly be regarded as established.

The authors have discussed very completely the various methods of treatment for nematode root-galls, and have experimented in detail with most of them. They reach the conclusion that "the most effectual, complete, and practical method of exterminating nematodes in greenhouses is by heating the soil by means of steam," which is both comparatively inexpensive and noticeably beneficial to the soil. While experimenting they noticed the comparative indifference of *Heterodera* to an atmosphere strong in CO_2. This is interesting as confirming for one free living representative of the group what Bunge long ago demonstrated for certain parasitic species. The paper is well illustrated and of permanent value.

2. A good résumé of present knowledge on the nematodes has recently appeared in the form of a somewhat popular article,[1] which

[1] Cobb, N. A. Extract from Manuscript Report on the Parasites of Stock, *Miscell. Publ. Dept. of Agr. Sidney, N. S. W.*, No. 215; also from *Agr. Gazette N. S. W.* (March and April, 1898), 62 pp., 129 text-figures.

contains also noteworthy contributions from the work of the author. The reader is struck at the outset by the breezy character of the author's style, especially noticeable in the first part of the paper on the methods of manipulation, which contains an energetic appeal to study of the group by a wider circle and full directions for carrying on the work. In the second part the anatomy and physiology of these worms are discussed topically under the various systems. Among the more important points which are new may be mentioned a tabulation of the various forms assumed by the pharynx and œsophagus, together with a terminology for the same. Microchemical demonstration of different uric compounds in preparations of the lateral fields strengthens the belief that the ducts in them are associated with the excretory function.[1] The author argues for a respiratory function of the problematical "lateral organs" present in varying form and development in all (?) the free-living forms, but wanting in the parasitic species, and gives some personal observations on the structure of these little known organs in new members of the group. Various hints make it evident that the author has some radical improvements to suggest on the classification of the nematodes. It is to be hoped that they may be published soon, as the present confusion in the group is exceedingly unfortunate for all students.

The article is illustrated by numerous exceedingly well made woodcuts which represent in many cases new species unaccompanied by any further description than the formula after the fashion set by the author for nematodes, yet the advantage of accurate figures is at once evident. Though the cuts are small and somewhat difficult to decipher, they are very exact, and it is agreeable to see illustrations which are new and which represent the real conditions rather than the author's diagrammatic conception of structure; were these figures only a little larger and more distinct they would be ideal.

H. B. W.

Origin and Development of Sense Organs.—Three popular scientific lectures on the origin and development of sense organs and sensory activities in the animal kingdom have been given by Dr. P. Steffan before the Senckenbergian Natural History Society.[2] In his intro-

[1] The recent researches of Nassonow, *et alii*, have appeared since the publication of the article.

[2] Steffan, P. Entstehung und Entwickelung der Sinnesorgane und Sinnesthätigkeiten im Tierreiche, *Ber. Senckenb. Naturf. Gesell.*, Frankfort a/M. (1898), pp. 29–69.

duction the author points out the dependence of our higher mental activities on the materials furnished by our sense organs. Light, heat, sound, materials of taste and of smell, and direct external contact are the stimuli for the eye, ear, tongue, nose, and outer skin. These, the author declares, are all the forms of sensory stimuli and sense organs known. How such a statement is consistent with the author's opinion as to the source of all our mental materials is difficult to understand, unless he be a man to whom pain, fatigue, hunger, and thirst are unknown.

The relation of sense organs to the medium in which the animal lives is next taken up. Organs of taste and touch are equally possible to water- and air-inhabiting animals, but organs of smell, hearing, and sight are of necessity more restricted to the air-inhabiting forms. Smell, the author believes, is absolutely impossible to water animals, though he offers no explanation of the condition in fishes where the organs which become olfactory in the air-inhabiting vertebrates are so well developed.

The remainder of the lectures is devoted to a condensed account of the sense organs of the animal kingdoms. The so-called vegetative senses—touch, smell, and taste—are first considered, and then what are dignified by the title of animal senses—hearing and sight—are dealt with. Practically nothing novel is introduced in this part of the work, the first portion reading like an abstract of Jourdan's *Senses and Sense Organs of the Lower Animals*, and the second being in large part avowedly taken from Carriere's little book on the eye. The popular treatment of a scientific subject is one of the most difficult tasks an author can set for himself, and to prescribe rules for such forms of composition is well-nigh impossible. Superficiality, however, is never to be tolerated, and superficiality is the characteristic of Dr. Steffan's contribution. G. H. P.

Eckstein's Zoologie.[1]—The German medical student has to pass examinations in zoölogy and comparative anatomy, and as a result a number of these compendia exist, apparently intended to enable the student to cram for examination. We are familiar with several of these syllabi, and this of Eckstein seems, on the whole, the best. It contains a large amount of information, clearly arranged under the heads of history, histology, comparative anatomy, physiology, embryology, paleontology, geographical distribution, phylogeny, taxonomy,

[1] Eckstein, Professor Dr. Karl. *Repetitorium der Zoologie, Ein Leitfaden für Studierende.* Zweite Auflage. Leipzig, W. Engelmann, 1898. 8vo, viii + 435 pp.

and the relations of animals to human interests. The book is well illustrated with two hundred and eighty-one cuts, none of which indicate the source from which they were copied.

Crustacea of Norway. — We wish to call attention to the valuable work by G. O. Sars[1] on the Crustacea of Norway, of which the second volume, treating of Isopoda, is now current. Every species is figured, often an entire plate being devoted to the figures of the entire animal and enlarged views of appendages. The text contains a brief description of every species, with valuable remarks on occurrence and distribution, and with synonymy. The last parts have treated of the Oniscidæ (wood lice, etc.), which have a special interest as being the sole large group of terrestrial Crustacea. From the fact that North American Crustacea closely resemble the Norwegian ones this work is of great value to American naturalists who are not regardless of the need of carefully identifying the species they study.

Japanese Pulmonates. — Dr. Jacobi[2] has made a thorough anatomical research on twenty-eight species of Japanese shell-bearing Pulmonata belonging to the genera Helecarion, Conulus, Ganesella, Helix, Eulota, Acusta, Euhadra, Plectotropis, Ægesta, Eulotella, Tristropeita, Slercophædusa, Bulimus, Succinea, and Limnæa. This is conscientious work of a much needed kind, unfortunately limited to alcoholic material; a compact mass of information, free from generalizations. The plates are excellent.

F. N. Balch.

Brooding in Frogs. — The singular brooding habits of a small frog, *Arthroleptis Seychellensis*, from the Seychelle Islands, are described by Professor August Brauer in the current number of Spengel's *Zoologische Jahrbücher*. The eggs are laid in damp places on the ground, and are kept covered and moist by the male until the larvæ are hatched, which occurs at the stage when they are provided with a long tail, and the first traces of the posterior appendage make their appearance. After hatching, the tadpole-like larvæ crawl upon the back of the male and attach themselves by the abdomen by means of secretions elaborated both by the larvæ and the adult.

[1] Sars, G. O. *An Account of the Crustacea of Norway*, vol. ii, Isopoda. Bergen, published by the Bergen Museum, 1897 and 1898.

[2] Jacobi, A. Japanische beschalte Pulmonaten, *Jour. Coll. Sci. Imp. Univ. Tokio*, XII, Pt. I. 102 pp., 6 plates.

Boulenger, in his account of the Venezuelan *Phyllobates trinitatis*, believed that the larvæ attached themselves to back of the parent with the object of being transported from one pool to another. Brauer shows, however, that in Arthroleptis the attached condition is not a temporary one, but that a large part of the development takes place in the back of the male.

Marine Mollusca in the Suez Canal. — M. Bavay (*Bull. Soc. Zool.*, France, XXIII, 9 and 10) gives a list of twenty-five species of marine Mollusca that have been taken in the Suez Canal, six of which are Mediterranean forms, and nineteen belong to the fauna of the Red Sea; of the latter, *Meleagrina radiata* has also been taken on the coast of Tunis. The disparity between the number of Mediterranean and Red Sea forms is explained by the fact that from July to January the level of the Mediterranean is at an average of .4 of a meter higher than the Red Sea, thus causing a current in the canal from north to south, while from January to July the level of the Red Sea stands .3 of a meter higher than the Mediterranean, producing a current from south to north. Now since it is in the earlier months of the year, or during the time of the northward current, that most of the larvæ are hatched, the Red Sea forms are most favored in their migrations.

Hertwig's Summaries in Systematic Zoölogy. — Professor A. A. Wright, of Oberlin College, has put into tabular form the classification adopted by Richard Hertwig in his *Lehrbuch der Zoologie*, and has printed with this a translation of the summaries of morphological and physiological facts given at the end of each chapter. His purpose is to make these summaries accessible to students as an accompaniment to lectures on systematic zoölogy. Professor Wright's pamphlet of thirty-five pages thus forms a useful supplement to Field's translation of the introductory part of the *Lehrbuch*, which covered the subject of general zoölogy. The first edition of Professor Wright's work, published in February, 1897, having been exhausted, a second edition without essential modification has recently been issued.

Fishes of Ecuador. — In the *Bolletino* of the museum at Turin Dr. E. A. Boulenger has a valuable paper on the fishes of Ecuador, collected by Dr. Enrico Festa. Forty-three species are described, many of them new. Among the latter are two marine catfishes, *Arius* (*Tachysurus*) *festæ* and *A.* (*Galeichthys*) *labiatus*.

A New Type of Shark. — Professor D. S. Jordan, in the *Proc. Cal. Acad. Sci.*, Ser. 3, *Zoöl.*, Vol. I, No. 6, describes the type of a

distinct family of Lamnoid sharks from Japan under the name of *Mitsukurina rustoni.* The genus is apparently unique among living forms, its nearest living relative being the genus Odontaspis of Agassiz, a group which contains few recent sharks, but which is rich in fossil forms.

American Gordiacea. — Dr. T. H. Montgomery concludes his second paper on Gordiacea of certain American collections (*Proc. Cal. Acad. Sci.*, Ser. 3, *Zoöl.*, Vol. I, No. 9) with a synoptical key for determining the species of Gordiacea of the North American continent north of Mexico.

Development of the Eel. — An excellent summary of our knowledge regarding the development of the eel is given by Dr. A. König in *Mittheil. d. Sect. f. Naturk. des Oesterreich. Touristen Club*, X, Nos. 8 and 9.

BOTANY.

A New School Botany. — The modern reaction against the old-fashioned way of making elementary botanical instruction consist chiefly in "analyzing" flowers is well exemplified in the present text-book.[1] With the recommendation that "analysis" be postponed, "even though the pupil may pursue it independently at a later time," the author introduces the student at once to a physiological and microscopical study of the protoplasm and vegetative organs of a few Algal, Fungal, Bryophytic, Pteridophytic, and Spermatophytic types. These same types, together with others, are then studied in the second part as regards their morphology, reproductive processes, and life history. This part ends with a cursory view of some of the more important families of flowering plants. A final part devoted to ecology calls attention to a few examples of interesting adaptations of various organs to the work of nutrition, protection, pollination, dissemination, and germination, and directs the student to profitable lines of study in geographical distribution with special reference to plant formations. In an appendix suggestions are given for the collection and preservation of material, note taking, etc.

The illustrations are mostly good, some being of unusual excellence. Certain of the photographic views, however, seem too hazy and con-

[1] Atkinson, Ph.B., George Francis, Professor of Botany in Cornell University. *Elementary Botany.* New York, Henry Holt & Co., 1898. xxiii + 444 pp., 509 illustrations. Cloth 12mo. $1.25.

fused to be of much significance to a beginner. A few of the drawings, as, for example, Figs. 44, 119, 189, 191, 192, 231, 232, 452, and 453, fall decidedly below the general standard of the book. Fig. 431 lacks the lettering necessary to make it significant.

Given a teacher well trained in physiological and microscopical work and a good school laboratory well equipped with modern though not expensive apparatus, this book will be found helpful and stimulating to both teacher and pupil. The student, however, if a beginner in botany, will frequently require the aid of such a teacher to make clear the meaning of passages which assume a knowledge of botanical matters dealt with only in a later chapter or not included in the book at all. Moreover, technical terms are often used before they have been explained, and sometimes different forms of the same word are used without explanation in a confusing way, as, for example, "chloroplast" and "chloroplastid" (p. 67), also "pollination" and "pollenation." It seems unfortunate and entirely unnecessary that the phrase *carbon conversion* should be substituted for the well-established term *photosyntax*.

It needs hardly to be said of a book from Professor Atkinson's pen that it abounds in information which is at once accurate and up to date. The only slips on matters of fact which the reviewer has noticed are the references to Trillium as having compound leaves (p. 313), to the "coral-root" orchid as having roots (p. 320), to the common bed-straw as having several leaves in a whorl (thus ignoring the stipular character of four of the leaf-like organs), and an incorrect floral formula on p. 254.

There are many evidences of hasty preparation and careless proofreading. Slips in English are not infrequent. Thus "shall" and "will" are continually misused, and one meets with such loose expressions as "alike in substance" for homogeneous (p. 5). One is rather surprised, too, at finding the peristome of a moss described as "frazzled."

In spite of its defects, the book is one of unusual interest and will doubtless hold an important place among advanced school books on botany.

F. L. SARGENT.

Microscopic Technique.[1] — As the author states, the writing of "Practica" is to be considered a somewhat thankless task, — it might be well, indeed, were it more generally so considered, — and a

[1] Meyer, A. *Erstes mikroskopisches Practicum.* Jena, Fischer, 1898. 100 pp., 29 figs.

good excuse is assuredly necessary to justify the publication of one. But this little volume, which, as is stated, is to be the first of a series, is not a mere copy or abridgment of preëxisting works of this sort. While from its extreme brevity of form it must, like many other elementary laboratory guides, present only a few rather isolated botanical facts, these facts are better correlated than in many similar books. It is, indeed, somewhat of a relief to find that no attempt is made to review the whole field of botany from A to Z. Possibly the author reserves this task for the more advanced "Practica," which are to follow. The table in which is set forth the most important characters of the tissue elements of angiosperms must prove convenient, at least in memorizing, if in nothing more.

H. M. R.

Schumann's Monograph of the Cactaceæ.[1]—In 1897 Professor Schumann, of the Botanical Museum at Berlin, issued the first Lieferung of a work which was intended to be completed in ten parts, and to contain descriptions, with synonymic references, for all of the sufficiently known species of cacti, as well as a chapter on the means of cultivating these interesting and sometimes beautiful plants. On the fifteenth of December, 1898, the publication of this work was completed by the printing of the thirteenth part, it having proved impossible to condense the entire matter into the limits originally proposed.

Probably there is no more complete nor representative collection of living cacti than that which Professor Engler, the Director of the Berlin Garden, has brought together within the last ten years, and there certainly is no botanist who has of late given so much continuous and careful study to the cacti as has Dr. Schumann. The work which he has just finished publishing is therefore one destined to take foremost rank in the hands of all students of the group, whether botanists or gardeners. The descriptions and keys are concise and, in the main, good. The synonymy adopted, which, as might be supposed, has been conformed to the Berlin rules, is conservative, and therefore reasonably satisfactory. The limitation of species has been effected on very conservative grounds, and while there is little doubt that some of them, as here accepted, will soon be redivided by Dr. Schumann or others, it is far better to have erred in this direction than by the multiplication of names for forms which

[1] Schumann, K. *Gesammtbeschreibung der Kakteen* (Monographia Cactacearum). Mit einer kurzen Anweisung zur Pflege der Kakteen, von Karl Hirscht. Neudamm, 1899. 8vo, xi + 832 pp., 117 ff.

ordinary people cannot separate. The illustrations are well chosen and, for the most part, excellent. Many of them are photo-engraved from drawings copied from classical figures, the source of which, unfortunately, is somewhat obscured by the statement that they are original. T.

Sargent's Silva.[1] — When it was begun, this superb work was intended to be completed in twelve volumes. The twelfth volume, however, recently issued, contains an announcement that a thirteenth volume will be devoted to supplementary material and an index to the entire work. Like its predecessors, the present volume is conservatively prepared and exquisitely published. It deals with the genera Larix, Picea, Tsuga, Pseudotsuga, and Abies. T.

Systematic Plant Anatomy. — Dr. Solereder, whose studies on the anatomy of flowering plants as applied to their classification are known to all botanists, has undertaken the preparation of a synopsis of what is known in this respect of the Dicotyledons.[2] The work is to be completed in four parts, and, though somewhat expensive (36 marks), will be a necessary and welcome addition to every working laboratory. T.

Botanical Notes. — The relation of plants to their surroundings is discussed in an entertaining way by Costantin, in a recent volume of the *Bibliothèque Scientifique Internationale.*

The anatomical means of distinguishing the commonly cultivated barberries are given by Koehne in *Gartenflora* for January.

Systematic plant introduction, its purposes and methods, is discussed by D. G. Fairchild in *Forestry Bulletin No. 21* of the Department of Agriculture.

A series of illustrated articles on the morphology of Anemone, by Janczewski, is brought to a conclusion in the *Revue Générale de Botanique* for December 15.

Orchid hybridizing, now a matter of some commercial importance, as well as of scientific interest, is described by C. C. Hurst in *Nature* for December 22.

[1] Sargent, Charles Sprague. *The Silva of North America.* Illustrated with figures and analyses drawn from nature by Charles Edward Faxon. Boston and New York, Houghton, Mifflin & Co. Vol. xii. vii + 144 pp., 26 plates.

[2] Solereder, H. *Systematische Anatomie der Dicotyledonen.* Ein Handbuch für Laboratorien der wissenschaftlichen und angewandten Botanik. Stuttgart, Enke. Lieferung 1, 2. 1898.

The *Bulletin of the Torrey Botanical Club* for January contains No. 5 of Professor Nelson's papers on New Plants from Wyoming, and a description and figure of *Lacinaria cymosa*, by H. Ness.

Thirty poisonous plants of the United States are described and, in large part, figured, by Chesnut in *Farmer's Bulletin No. 86* of the Department of Agriculture.

Of interest to botanists is a portrait of Sir W. T. Thiselton Dyer, K.C.M.G., the able director of the Royal Gardens, Kew, published in the *Gardener's Chronicle* of January 7.

In the *Berichte der deutschen botanischen Gesellschaft* of December 28, Ule speaks of the adaptation of some Brazilian Utricularias to their mode of life, which is peculiar, since they live in the leaf rosettes of certain Bromeliaceæ.

Under the title Plantæ Mattogrossenses, Dr. J. Barbosa Rodrigues, director of the botanical garden of Rio de Janeiro, publishes descriptions and figures of a considerable number of new or little known species.

The Bermuda Juniper and its allies are disentangled by Dr. Masters in the *Journal of Botany* for January. While the Jamaican tree is referred to *J. Virginiana*, our common red cedar, the tree of Bermuda, *J. bermudiana*, is held to be specifically distinct.

The Iowa Sedges are catalogued, with synonymic notes, by Professor Cratty, in the December number of the *Bulletin of the Laboratory of Natural History of the Iowa University*. The list includes 114 species and varieties, pertaining to 10 genera. Ten species are figured.

Cerastium arvense, var. *oblongifolium*, a form of a common enough weed, is christened The Starry Grasswort and recommended for decorative cultivation by Professor Arthur in *Bulletin No. 74* of the Purdue University Experiment Station.

The *Journal of the Royal Horticultural Society* for January contains the following articles of botanical interest: Economic uses of bamboos, and list of bamboos in cultivation; Water-lilies and hybrid water-lilies, the latter by the well-known raiser of such hybrids, M. Latour-Marliac.

The Botanical Gazette begins its twenty-seventh volume with an interesting address on the vegetation of tropical America, by Professor Warming, whose studies of Brazilian plants are well known.

The same number contains an elaborate paper on the life history of *Lemna minor*, by Otis W. Caldwell.

Möllers Deutsche Gärtner-Zeitung of January 14 contains an article on Mexican orchids in their native home, by Othon Krieger, which is illustrated by reproductions of two photographs presenting a very vivid picture of the abundance of these epiphytes of our plant-houses and of the difficulties attending their collection.

Botanists who may make the acquaintance of the white ash of Australia will not find a species of Fraxinus, but a Eucalyptus, which has been described and figured by Deane and Maiden in No. 91 of the *Proceedings of the Linnæan Society of New South Wales* under the name *E. fraxinoides*. The same number contains descriptions and figures of two additional species of Eucalyptus, by R. T. Baker.

GEOLOGY.

The Isthmus of Panama, as has been shown by a geological reconnoissance made by R. T. Hill,[1] is an ancient mountain range much reduced in height and deeply dissected by erosion. The drainage system is well developed and consists of several principal streams, which have many rapidly flowing branches near their sources, but comparatively long, low-grade trunks into which the tides extend many miles from the sea. The larger streams generally are characterized by drowned mouths and actively corrading head waters.

There is an absence on each border of the isthmus of a coastal plain, similar to that on the Gulf and Atlantic borders of the United States. The uplands come boldly down to the sea in a series of bluffs and headlands, separated by the partially drowned valleys. On each shore, however, there is a submerged platform, which extends out to about the 100-fathom line, where the bottom descends rapidly into water of great depth. The topography of these submerged shelves indicates that they were formerly coastal plains across which the present streams were extended and excavated channels. A downward movement of the land has submerged the former coastal plain and given origin to coastal swamps, and permitted the encroachment of the sea far up the ancient, low-grade valleys.

[1] Hill, R. T. The Geological History of the Isthmus of Panama and Portions of Costa Rica. Based on a reconnoissance made for Alexander Agassiz. *Bulletin of the Museum of Comparative Zoölogy at Harvard College*, vol. xxviii (1898), No. 5, pp. 151–285, with 19 plates.

The lowest pass across the isthmus, which is a drainage col between the head waters of two opposite flowing streams, is but 287 to 295 feet above the ocean. If the isthmus should subside about 300 feet, a connection would be made between the waters of the Atlantic and the Pacific. None of the passes through the mountains, however, give evidences of ever having been straits connecting the bordering oceans. One of the most important conclusions reached by Hill from several lines of investigation, is that there has been no oceanic connection across the isthmus since Tertiary time. There is, indeed, considerable evidence that this land barrier has existed since Jura-Trias time, with perhaps a shallow passageway across at the close of the Eocene; but even this ephemeral connection has not been definitely proven. In a footnote the opinion is expressed that the Tehuantepec isthmus, composed of cretaceous rocks, has "remained land since its earliest origin."

The conclusion in this connection seems to be that the Central American and Mexican region has been above water at least since the close of the Tertiary. This is of special importance to the students of the Glacial epoch, inasmuch as a subsidence of a portion at least of the Central American region, and a consequent cessation of the Gulf Stream, has been postulated, on purely hypothetical grounds, to explain climatic changes in the northern portions of America and Europe. The antiquity of Central America is also of much interest to biologists, since it is in harmony with the well-known differences in most of the marine species in the waters it separates.

Much information is recorded by Hill in reference to the rocks of the isthmus, the geological structure, the decay of the surface material under a warm climate with excessive rainfall, etc. The appendices contain the following reports on the collections brought home: invertebrate fossils, by W. H. Dall; foraminiferal deposits, by R. M. Bagg; and igneous rocks, by J. E. Wolff.

The report is illustrated by three instructive sketch-maps in contours, which unfortunately are without titles or scales, four sheets of profiles and sections, and twelve reproductions of photographs, several of which illustrate scenes along the Panama Canal.

ISRAEL C. RUSSELL.

PETROGRAPHY.

Experimental Petrography. — Morozewicz[1] has just published a long paper on "Experimental investigations upon the formation of minerals in magmas" that will unquestionably take a place among the most important contributions to experimental geology that have been made within recent years. The author fused known mixtures of the various rock-producing compounds in a glass-furnace and thoroughly studied the resulting products. The conclusions reached by him are full of suggestiveness. The way seems to have been opened for a long line of important investigations to follow, some of which have already been entered upon.

The details of the experiments cannot be entered upon here, but some of the conclusions arrived at may be briefly indicated.

1. The structures of cooled magmas appear to depend upon exterior conditions of crystallization and upon their chemical composition, quantitative as well as qualitative.

2. The order of crystallization is determined by no one condition, such as fusibility, acidity, etc., but it depends upon a number of variable conditions, one of the most important of which is the quantity of the various constituents present as compared with their solubility in the molten mass. The ability of a substance to supersaturate the magma depends primarily upon its nature, the nature of the other substances composing the magma, and its temperature.

3. So far as the experiments touch upon the question of the differentiation of magmas, they seem to indicate that a molten mass may separate into layers or parts differing in density, and that this difference may be due to the fact that the bases FeO, MgO, CaO, separate as silicates by crystallization earlier than the remaining constituents.

Two pounds of granite, with the composition given below (I), were heated for five days. The mixture yielded a mass of glass which in its upper portion contained unmelted quartz grains and a considerable quantity of tridymite. Though the glass between the quartz grains in the upper portion of the crucible presented the same appearance as that in the lower parts, the composition of pieces taken from the two parts was found to be quite different. Under (II) we

[1] *Min. u. Petrog. Mitth.*, vol. xviii, pp. 1 and 105.

have the analysis of the glass from the upper part, and under (III) that of the glass from the lower portion.

	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	K_2O	Na_2O		Total.	Sp. Gr.
(I)	68.9	19.7	1.4	1.2	1.0	2.7	4.7	=	99.6	2.716
(II)	73.65	14.08	2.33	1.94	.65	2.61	3.86	=	99.12	2.2384
(III)	59.20	22.30	3.83	3.71	1.23	3.26	5.40	=	98.93	2.484

The Basic Rocks of Ivrea. — The basis rocks in the neighborhood of Ivrea, on the south side of the Alps, are shown by Schaefer[1] to be the result of cooling of a single magma. This yielded norites, diorites, gabbros, peridotites and both basic and acid dyke-rocks. The norites include hornblendic varieties, and the diorites, bronzitic, hornblendic, and biotitic phases. All these rocks have been subjected to the action of mountain-making forces. The norites have become schistose without suffering any essential mineralogical change. Some of the diorites have simply been made schistose, others have undergone a further change in that their dark, compact hornblende has passed over into a light green amphibole, while a final stage of alteration is represented by green schists, composed of zoisite, plagioclase, actinolite, chlorite, and epidote.

The dyke rocks cut the large basic masses and are always closely related to them chemically. The principal types are a labradorite (Labradorfels) and a fine-grained black rock which the author calls valbellite. This is made up of bronzite, olivine, and brown hornblende with pyrrhotite, spinel, and magnetite as accessories.

The Basalts of Steiermark. — Sigmund's[2] studies on the basalts of Steiermark are continued in an article in which are described the magma-basalts and basalt-tuffs of Fürstenfeld and the feldspar basalt of Weitendorf. The composition of the magma-basalt is shown by the figures below.

SiO_2	TiO_2	Fe_2O_3	FeO	Al_2O_3	CaO	MgO	Na_2O	K_2O	CO_2	H_2O		Total.
46.76	tr.	5.33	5.62	17.93	8.24	7.31	3.53	2.20	1.33	1.83	=	100.08

Petrographical Notes. — Reinisch[3] has found a specimen of teschenite in the museum at Minussinsk. It is labeled as having come from east of the salt lake Staniza on the river Bjelyi-Jjuss, Minussinsk parish, Jenisseisk gouvernement, East Siberia. It resembles very closely the West Carpathian rock. Among the other specimens from

[1] *Min. u. Petrog. Mitth.*, vol. xvii, p. 495.
[2] *Ibid.*, p. 256.
[3] *Ibid.*, vol. xviii, p. 92.

the same region, melaphyres, melaphyre-tuffs, granites, amphibolites, and contact metamorphosed limestones have also been identified.

Becke[1] records an analysis of the leucite-basanite lava of 1891–93 from Vesuvius as follows:

SiO_2	Al_2O_3	FeO	Fe_2O_3	CaO	MgO	Na_2O	K_2O	P_2O_5		Total.
48.99	19.82	5.26	2.59	8.13	2.82	3.17	9.06	.33	=	100.17

The tonalite gneiss of Wistra, Carpathia, has the composition:

SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	Loss.		Total.
63.09	18.89	3.48	2.02	1.97	6.18	3.14	1.30	.63	=	100.70

Coleman[2] gives a few brief descriptions of some of the rocks met with in the course of his studies of the gold regions of Western Ontario. Among them are diorites, diorite gneisses, a porphyrite, a pyroxenite, and a hornblende porphyrite from Grand Presque Isle, Lake of the Woods. The hornblende porphyrite consists of phenocrysts of hornblende, containing in their interiors remnants of augite and a ground mass composed of quartz, plagioclase, augite, and some orthoclase. Near Peninsula and Port Caldwell, on the north shore of Lake Superior, are coarse diabases, gabbros, augite-diorite, and porphyrites, and associated with them are red rocks, called by the author augite-syenites, diorites, and syenites. Some of the augite-syenites are aggregates of orthoclase and augite, while others are made up largely of pegmatite. Near Lake Wahnapital, in the Sudbury district, diabases, granite, arkoses, graywackes, and dolomites occur.

[1] *Min. u. Petrog. Mitth.*, vol. xviii, p. 94.

[2] *Rep. Bureau of Mines* (Ontario), 1898, p. 145.

NEWS.

In our January issue we announced the death of Dr. Vincenzo Diamare of the Institute of Comparative Anatomy of the University of Naples. We are unable now to trace the source of our information, but Dr. Diamare writes us that he is alive and well, and desires to live on. We wish Dr. Diamare a long and useful life and beg that he will forget our unfortunate error.

A botanical club has been organized in Washington with Professor Edward L. Greene as president and Charles L. Pollard as secretary.

The list of officers and councillors elected for the present year by the Philadelphia Academy of Natural Sciences is remarkable for the few names known to science.

The borings in the coral reef at Funafuti have been discontinued at a depth of 1114 feet. The drill was then in what is called "coral reef" rock, but as yet no studies have been made to ascertain whether it be of recent or extinct forms.

A movement is being inaugurated to increase the endowment of the University of Cambridge. $2,500,000 is desired, and two persons have already pledged $100,000.

The British Association meets in Dover this year.

There was an earthquake in Mexico, January 24, lasting three minutes. Three hundred houses were damaged and ten were completely destroyed.

At the R. I. College of Agriculture and Mechanic Arts (Kingston), the special course of instruction in poultry culture for 1899 began on January 9, to continue four weeks. Nearly forty applications for enrollment for the course were received, but owing to limited accommodations the class has been kept down to about twenty in number. Several who could not take this course have enrolled their names for the next in 1900.

Bulletin of the Cooper Ornithological Club is the title of a new bi-monthly bird journal, published in Santa Clara, Cal., under the editorship of Chester Barlow. The sphere of the journal will be

limited to the ornithological interest of the extreme west, more especially California, and will serve as the organ of the Cooper Ornithological Club.

Many naturalists will probably be interested to learn that the house of E. Merck, of Darmstadt, have begun the publication of a new magazine, *Merck's Digest*, which will give accounts of the various chemicals manufactured by the firm, with reports upon their physiological action. As we understand, the magazine will be supplied free to all chemists and physiologists applying for it.

A successor to E. Ray Lankester as Linacre professor of Comparative Anatomy in the University of Oxford will be elected this spring.

The Royal Microscopical Society has elected Mr. E. M. Nelson to the presidency.

The Russian Geographical Society has established a seismological observatory in Irkutsk, Siberia.

A natural history museum was opened at King Williams Town, Cape Colony, October 5.

Applications for the use of the American women's table at the Naples Zoological Station should be sent to Dr. Ida H. Hyde, 1 Berkeley Street, Cambridge, Mass. Dr. Hyde will give information as to cost of living, etc., to any who may wish it. Two students can occupy the table at the same time — a fact which in some cases would make the study in Naples more agreeable.

The Biological Laboratory of the Brooklyn Institute of Arts and Sciences, located at Cold Spring Harbor, Long Island, will be open for its tenth season during July and August, 1899. The regular class work occupies six weeks from July 5. Courses are offered in High School Zoology by Dr. C. B. Davenport, of Harvard University, who is also the Director of the Laboratory. In Comparative Anatomy, by Professor H. S. Pratt, of Haverford College; in Invertebrate Embryology, by Professor C. P. Sigerfoos, of the University of Minnesota; in Botany, especially of Cryptogams, by Dr. D. S. Johnson, of Johns Hopkins University, assisted by Professor F. O. Grover, of Oberlin College; in Bacteriology, by Mr. N. F. Davis, of Bucknell University; in Microscopic Methods, by Mrs. Gertrude Crotty Davenport, formerly instructor at Kansas University. Opportunities are afforded for Original Investigations, especially in the Variation of

Animals with reference to the Origin of Species, the latter work being under the direction of Dr. Davenport. The laboratory offers dormitory and boarding accommodations on the grounds and under the control of the director. The laboratory is equipped with a naphtha launch, bacteriological apparatus, and a good working library. The tuition fee is $20; board costs $4.50, and rooms $1.50 or $3.00 per week. Application for admission or for the announcements may be made to Professor Franklin W. Hooper, 502 Fulton Street, Brooklyn, N. Y., or to Dr. Charles B. Davenport, Harvard University, Cambridge, Mass.

Appointments: Mr. W. Anderson, of the Indian geological survey, director of the newly instituted geological survey of Natal; M. Güntz, professor of mineralogical chemistry in the Faculty of Sciences at Nancy; L. B. Wilson, demonstrator in pathology and bacteriology in the University of Minnesota.

Deaths: Dr. Giuseppe Bosso, bacteriologist in the University of Turin, January 17; Wilhelm Dames, professor of geology and paleontology in the University of Berlin, December 22, aged 55; Fr. Gay, of the University of Montpellier, France, a student of the algæ, aged 40; Major Jed. Hotchkiss, of Staunton, Va., a well-known writer on subjects in the field of economic geology, January 18, aged 71; Pastor Christian Kaurin, of Sand Jarlsberg, Norway, student of mosses, May 25, 1898, aged 66; Henry Alleyne Nicholson, professor of natural history in the University of Aberdeen, and well known for his textbooks and his paleontological researches, January 19, aged 54; T. Caruel, professor of botany in Florence, Italy.

CORRESPONDENCE.

THE TRUE FUNCTION OF THE UNIVERSITY OF THE UNITED STATES.

The following contribution to the discussion opened by Dr. Dall in the February *American Naturalist*, on the subject of a university of the United States, has been received from the recording secretary of the George Washington Memorial Association. — Ed.

To the Editor of the *American Naturalist:*

Sir, — With the growth of the graduate departments of existing universities of the United States, a growth which would astonish any one who had not been in the closest relation with one or many of these universities, the need which existed a few years ago for a national graduate university, with instruction leading to the Doctorate, is gradually diminishing. There is, however, left for the proposed University of the United States a unique field, one which the universities of the states cannot hope to fill — that is, the encouragement and support of research.

The fact may as well be faced that the general education of an undergraduate college course, with at the best a thesis on some special point, does not fit one to take up a subject for research and treat it broadly. The rapid progress in all branches of science makes it necessary that for a genuine advance into new fields of knowledge long and careful training in methods is necessary. The thesis for a Doctorate is in the majority of cases an expression of this careful training under the eye of a master, the subject of the thesis having been suggested by the master, and its progress watched and directed week by week; hence with the taking of the Doctor's degree, but not before, the student is well prepared to take up an independent piece of work.

In the bill before the Senate Committee on the University of the United States is a section which should not be lost sight of or slurred over. It is: "The University shall have authority to establish with other institutions of education and learning in the United States such coöperative relations as shall be deemed advantageous to the public interest."

In a wide interpretation of this section is, it seems to me, the solution of the vexed question of the University of the United States.

The Morrill Bill of 1862, which gave the foundation of many of the state colleges — with its supplement of 1890 — and the Hatch Bill of 1887, which founded the Agricultural Experiment Stations, together form the basis for higher education and research in the states at the expense of the national government. An extension of this kind of support to the higher departments of learning in the states would disseminate the interest and give opportunity for training in research. By this means all of the degree-conferring machinery of a national university could be relegated to the universities of the states.

The selection which Dr. Dall, in the *American Naturalist* for February, mentions as necessary before students shall be admitted to opportunity in the government departments at Washington would thus be accomplished. A thesis for Doctorate would be the test for ability to use the opportunity.

By generous coöperation certain resources of the departments could be used by a special student without expecting instruction in the ordinary sense from the chief of divisions, and thus not be a burden.

The recent address of President Harper before the University Club of New York outlines a plan for a federation of universities which may make the basis for a national university. Some such plan as this, modified by the combined wisdom of a committee of experts, can surely solve the problem of the university side of the question, *i.e.*, what branches of learning can to best advantage be furthered in any one university.

The unification of the Scientific Bureaus of Washington, the exact degree in which they can give opportunity for research without impairment of their usefulness, — these questions should be discussed and carefully considered by experts also; but the serious difficulty of opening these Bureaus to students comes from the possible great number of applicants who would be attracted by a free opportunity. There are 4000 graduate students in the universities of the United States. The number is rapidly increasing, and there may before long be 10,000 students who might apply for admission to opportunity in Washington, thus embarrassing and clogging all work. Therefore a larger outlook must be taken by those who advocate a national university. A plan must be devised whereby the government may do its share toward the support of graduate instruction in universities and also more generously support the real research done under government auspices.

The government lands are, perhaps, too nearly exhausted to make

possible a repetition of the Morrill land grant to the states; but it would be possible to issue 5% bonds which benefactors of higher education could buy for the support of graduate work in a special institution. By making these bonds inalienable a permanent fund would be established. The low ruling rate of interest would thus make the matter a genuine piece of coöperation on the part of the government, and in so far as the 5% exceeds that rate there would be a government grant.

It is, then, to emphasize the fact that the most recent thought concerning the formation of a national university does not contemplate flooding the District of Columbia with a body of untrained or partly trained students that this letter is written. It is desired that the government foster research, establishing a national university with branches, providing in the central establishment broader opportunity for research, increasing in the state branches the facilities for training graduate students.

SUSANNA PHELPS GAGE.

ITHACA, N. Y., February 9.

GASKELL'S THEORY OF THE ORIGIN OF VERTEBRATES FROM CRUSTACEAN ANCESTORS.

To the Editor of the *American Naturalist:*

SIR, — Since the Annelid theory of the origin of vertebrates, at one time so generally and enthusiastically advocated, has failed to realize the expectations of its adherents, interest in the subject has steadily fallen off, and the various attempts to substitute something in its place have gained only individual or, at most, a very small number of followers.

The impression has steadily gained ground that in spite of its very great importance the problem of the origin of vertebrates is no longer a fruitful one for discussion, because the evidence accessible is so general in character that one may make out a reasonable theory based on almost any invertebrate that one may be pleased to select. We believe, however, that there is no reasonable justification for this state of mind, and that perhaps it may be in a measure overcome by showing how any radical departure from certain lines of procedure, even if the utmost liberty is exercised in the destroying of old organs and the creation of new ones, fails to make the solu-

tion of this problem any easier, and in the end leads to hopeless confusion. It will, therefore, be interesting and profitable to consider some of the difficulties into which Mr. Gaskell is led in his attempts to solve this problem by the novel method of comparing the dorsal surface of an arthropod with the dorsal surface of a vertebrate.

It may be stated incidentally that Mr. Gaskell adopts, without acknowledgment, the same lines of argument in reference to many homologies between vertebrates and arthropods that were used in my first paper on this subject in the *Quarterly Journal.* This is notably the case in regard to the paleontological evidence, the relation of the endosternite of arachnids to the cartilaginous cranium of vertebrates, and to the causes for the disappearance of the old mouth in the concentration of the thoracic neuromeres around the arachnid œsophagus, although these facts are quite inapplicable to his theory.

Briefly stated, Gaskell maintains (*Journ. of Physiol.*, 1889, p. 191) that the nervous system of vertebrates is composed of two essentially different parts: first, a preëxisting, non-nervous tube, consisting of the epithelium of the canalis centralis and cerebral vesicles, and the various supporting elements derived from it; and, second, the true nervous elements, consisting of a "bilateral chain of ganglia connected together by means of longitudinal and transverse commissures." The infolding of the medullary plate of vertebrates shows us, he maintains, the simultaneous development of two different organs, the one the nervous system, and the other the tube of supporting tissue, p. 193. This tube of supporting tissue, "which is not nervous and never was nervous," and which is coextensive with the canalis centralis and the cerebral ventricles, Gaskell regards as the remnants of the alimentary canal of a crustacean-like ancestor. The ventral cord and the supraœsophageal ganglia of the crustacean ancestor have in vertebrates fused with and grown around the old alimentary canal to form the true nervous elements of the spinal cord and brain. *No reversal of surfaces is called for by this transformation*, for the ventral surface of an arthropod is regarded as homologous with the ventral side of a vertebrate. . . . He maintains that the one reason why they (the champions of the origin of vertebrates from the appendiculata) have not been able to make any real advance in their views, has been the difficulty of accounting for the altered relations of alimentary canal and nervous system in the two groups. His theory "solves this difficulty,"

not by turning the animal over, but by transporting bodily the crustacean nerve cords and alimentary canal from the ventral to the dorsal side. By this simple process everything of importance that happens to lie between the dorsal and ventral surfaces must be either swept out of existence or forced into some corner where it undergoes extensive and complete degeneration. The result is a metamorphosis so profound that morphologists have completely failed to recognize the organs of the crab in their new forms and places. According to Gaskell, during the transition from crustacea to vertebrates, the crab's heart is nearly crowded out through the back by

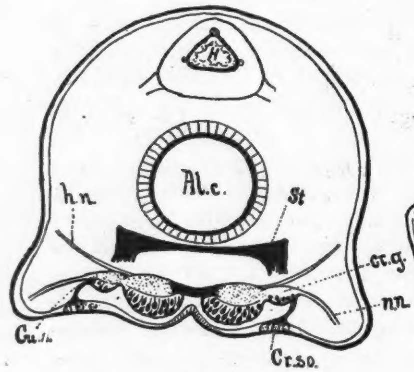

FIG. 1.

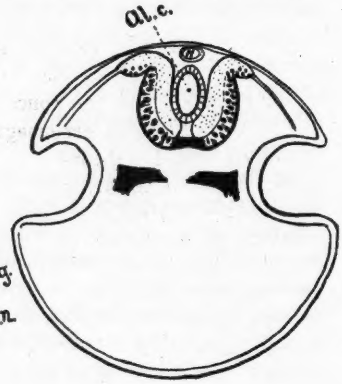

FIG. 2.

FIG. 1. — Diagrammatic cross-section of an arachnid (Limulus) in the head region, showing the relative position of heart, alimentary canal, endosternite, and principal peripheral nerves and commissures.

FIG. 2. — Cross-section of a vertebrate illustrating Mr. Gaskell's theory that the arthropod nerve cords, alimentary canal, and endosternite have been transferred to the original dorsal surface where the heart and alimentary canal undergo extensive degeneration.

the dorsal movement of the nerve cords, although it still lingers in Ammocœtes, where he has detected it as "that peculiar elongated organ, composed of fattily degenerated tissue, which lies between the spinal cord and the dorsal median skin." It is not clear whether it was the peculiar elongation of the organ or the presence of fat in it that enabled him to recognize the heart of Limulus in such an unusual place. Gaskell also proves, in the same manner, that the nephridia, or coxal glands of arthropods, have been disguised as the pituitary body of vertebrates; the genital part of the opercular appendages, as the thyroid glands and pseudo-branchial groove; and he shows how the gigantic liver of crustacea is reduced to a mass

of "sub-arachnoidal glandular tissues," that helps fill up the cranial cavity, and thus keeps the brain in place. The straight intestine is discovered under the guise of the central canal of the spinal cord and the "cephalic stomach" as the ventricular cavities of the brain. These are only a few of the renovations to which the crabs must submit in their efforts to become vertebrates. There is not much left that can be used to advantage in the "new crab," except the skin and bones, and Gaskell makes a good deal of them, although he does not display as much ingenuity in doing so as in some of the instances quoted above, because the essential points of resemblance between the cartilages and the dermal structures of Limulus and those of vertebrates have already been pointed out by the author. Gaskell hopes to explain some time how our eviscerated ancestors acquired a new heart, kidneys, and productive organs, as well as a new alimentary canal complete, from mouth to anus.

Gaskell argues that he is justified in "violating the embryological unities," as he calls them, on the grounds that there is much scepticism abroad concerning the validity of the germ layer theory. But this weakness of the germ layer theory can hardly be construed as a license to transfer a crab's entire alimentary canal and nervous system from the ventral to the dorsal surface without obtaining some authority from established facts, yet the assumption that this transfer has taken place forms the foundation of Gaskell's theory. The conception is untenable, not because the supposed transfer of organs is a novel and surprising one, or because it is difficult to see how the animal could survive the operation, but because it assumes a condition of affairs that does not exist, because the peripheral nerves and the cross commissures present impassable barriers to the proposed changes, and because the suggestion is inconsistent with the most obvious facts of embryology.

In 1896 (*Nature*), about eight years after the idea first occurred to him, Professor Gaskell is led to suspect that there may be some difficulties in homologizing the hæmal surface of a crab with the neural surface of a vertebrate, and gives the following explanation:

The ontogenetic test appears to fail in two points:

(1) "That the nerve tube of vertebrates is an epiblastic tube, whereas, if it represented the old invertebrate gut, it ought to be largely hypoblastic.

(2) "The nerve tube of vertebrates is formed from the dorsal surface of the embryo, while the central nervous system of arthropods is formed from the ventral surface.

"With respect to the first objection, it might be argued, with a good deal of plausibility, that the term 'hypoblast' is used to denote that surface which is known by its later development to form the alimentary canal, that in fact, as Heymons has pointed out, the theory of the germinal layers is not sufficiently well established to give it any phylogenetic value." Are we to understand from this that since the canalis centralis does not develop into an alimentary canal, it is probably hypoblastic?

"The second objection appears to me more apparent than real. The nerve layer in the vertebrate, as soon as it can be distinguished, is always found to lie ventrally to the layer of epiblast which forms the

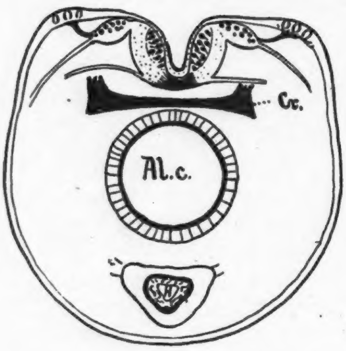

FIG. 3.

FIG. 4.

FIGS. 3, 4. — Cross-sections of a vertebrate in the head region, illustrating how the vertebrate condition may be attained by turning the arthropod over on to its dorsal surface, thus bringing its principal organs into the same relative position as in vertebrates. No degeneration of old organs or formation of new ones is required according to this view. The epithelium of the canalis centralis and ventricles thus appear not as parts of an old alimentary canal, but as the infolded ectoderm that from the first overlies the brain and spinal cord, and from which they are phylogenetically as well as ontogenetically derived.

central canal. . . . The nerve layer in the arthropod lies between the ventral epiblast and the gut; the nerve layer in the vertebrate lies between the so-called hypoblast (*i.e.*, the ventral epiblast of the arthropod) and the neural canal (*i.e.*, the old gut of the arthropod). The new ventral surface of the vertebrate in the head region is not formed until the head fold is completed. Before this time, when we watch the vertebrate embryo lying on the yolk, with its nervous system, central canal, and lateral plates of the mesoblast, we are watching the embryonic representation of the original Limulus-like animal; when the lateral plates of the mesoblast have grown round,

and met in the middle line to assist in forming the new ventral surface, and the head fold is completed, we are watching the embryonic representation of the transformation of the Limulus-like animal into the scorpion-like ancestor of the vertebrates."

It is not quite clear what Mr. Gaskell means by the above statement, but if I understand him correctly, it is clear that if the embryonic shield of a vertebrate embryo represents an arthropod embryo on the old arthropod hæmal surface, then the growing margins of the mesodermic area must lie *between* the nerve cords, and they should grow toward the mid-dorsal line and concresce there. But nothing of the kind is to be seen in vertebrates, because the mesoderm lies mainly *lateral* to the nerve cords, and grows in the opposite direction to what it should according to Gaskell's theory, namely, toward the vertebrates' true hæmal surface. Moreover, the transformation of the "Limulus-like animal into the scorpion-like ancestor" should show us not merely the growth of the mesodermic plates, but the migration of the canalis centralis and the nerve cords from their first position in the embryonic shield of a vertebrate (*i.e.*, the Limulus condition) to the opposite side of the egg, *i.e.*, the vertebrate position. But the nerve cords and canalis centralis are already in their permanent vertebrate position, and for that very reason, according to his own supposition, they cannot also be in the Limulus position! The reader may perhaps doubt whether Gaskell, in his earlier papers, thought that the alimentary canal of arthropods arose from the dorsal or the ventral surface of the egg. If he supposed it arose from the ventral surface between the nerve cords, then how can it appear in vertebrates at the very outset of development at the opposite side of the egg? Consultation of the text leads one to suspect that the difficulty is to be solved by taking the entire roof off the crab, leaving nothing but the ventral surface behind, for he also claims that in vertebrates the infolding of the medullary plate represents the simultaneous development of the nerve cords and alimentary canal of the ancestral crab, hence they must appear on what was the ancestral ventral side, so that we must suppose the medullary plate of vertebrates is seen through an imaginary dorsal portion of the ancestral crab, like the coat-tail buttons on the back of Marley's ghost; or, if he wishes to avoid this dilemma by an appeal to the tottering theory of concrescence, he will be forced to look on the vertebrate blastopore not as the original mouth of a remote ancestor, but as the entire dorsal surface and sides of a crab, into which are gradually swept all the organs which, in a crustacean, lie dorsal to the nerve cords and

alimentary canal. If Mr. Gaskell accepts this alternative, he will find it difficult to explain how the alimentary canal of the ancestral crab was split into two surface cords of cells that sweep round to the opposite side of the ovum to form the canalis centralis of vertebrates.

Gaskell bases his comparison of the pineal eye of vertebrates with the ocelli of arthropods mainly on their minute structure, neglecting their mode of development and the fact that there are two distinct types of arthropod ocelli, namely, the paired ocelli, with upright retinas, as in Dytiscus and Hydrophilus, and the ocelli with inverted retinas, formed by the fusion in the median line of two or more ocelli (*e.g.*, median ocelli of scorpions, Limulus, and possibly some crustacea). As we have shown elsewhere, the latter are the only ocelli that can be compared with the pineal eye of vertebrates, both on account of their position and the fact that they are the only ocelli which lie at the end of tube-like outgrowths from the roof of a cerebral vesicle. This condition is brought about in scorpions and in Limulus by the overgrowth of a lateral fold of ectoderm, which in the scorpion completely encloses the cephalic lobes or forebrain, leaving the inverted ocelli at the end of a tubular outgrowth of the roof of the vesicle. This is one of the most satisfactory indications we have of a relation between vertebrates and arthropods, for it shows us in detail how the eyes of vertebrates have in all probability been inverted and transferred from the lateral edges of the cephalic plate to the ends of tubular outgrowths of a cerebral vesicle. In Gaskell's earlier paper (*Quart. Journ.* p. 50, 1889) he compares the pineal eye of vertebrates with the ocelli of Dytiscus and Hydrophilus. He then constructs a diagram of the vertebrate pineal eye, which is almost an exact copy of the ocelli of Dytiscus, and this diagram is printed in three colors, to show that the pineal eye of vertebrates "is clearly that of an arthropod, and indeed of an ancient form" (p. 53, 1889). As a matter of fact, however, the ocelli of Dytiscus and the pineal eye of vertebrates are not in the least alike, and the mode of development in the two cases is entirely different. On the other hand, the median ocelli of scorpions and of Limulus do resemble in a most striking way, in their position and development, the pineal eye of vertebrates. These ocelli *already lie at the end of a tubular outgrowth from the roof of a forebrain vesicle.* These facts perhaps escaped Gaskell's attention, although they were described in the same number of the *Quarterly Journal* as his earlier paper. They are fatal to his view that the forebrain vesicle is a remnant of an arthropod alimen-

tary canal, because if the arthropod brain is already hollow, why should any one introduce the alimentary canal into it in order to explain why the brain is hollow in vertebrates?

I have described in the same number of the *Quarterly Journal* in which Gaskell's earlier paper appeared how the cartilaginous endosternite in scorpion and Limulus is comparable in shape and in its relations to the brain and alimentary canal with the primordial cranium of vertebrates, and how a complete ring is formed about the posterior part of the brain, like the occipital ring seen in the early stages of

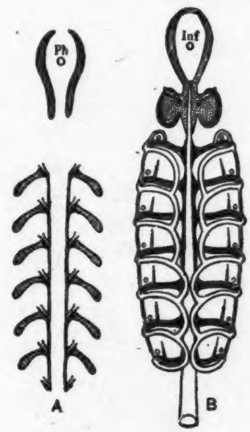

FIG. 5. — Gaskell's diagrams of the cartilages constructed by him to show how much the cartilaginous skeleton of Limulus, A, resembles that of Ammocœtes, B.

the cartilaginous cranium of vertebrates. Gaskell makes no reference to these facts, but nevertheless he lays great stress on the presence of the endosternite, although it lies on the opposite side of both the nervous system and the alimentary canal from what his theory demands. To meet the requirements of his theory, the endosternite must first be split in halves lengthwise, and the two parts transferred to the opposite side of the nervous system, and then, after their reunion, a new occipital ring must be formed on the opposite side of the sternite from the one where it actually is formed in the arachnids. (Compare Figs. 1 and 2.) And before all these changes could take place, the long fragments of the sternite would have to plough their way through the nervous system, beneath the epithelium of the cerebral vesicles and the canalis centralis (Fig. 1). But even then,

6

to get entirely out of the trap, they would have to break through either all the cranial nerves, if they passed out laterally to the nerve cords, or else all the cranial cross commissures, if they passed between them.

In order to make the similarity between the cartilages of Ammocœtes and those of Limulus more apparent, Gaskell produces two

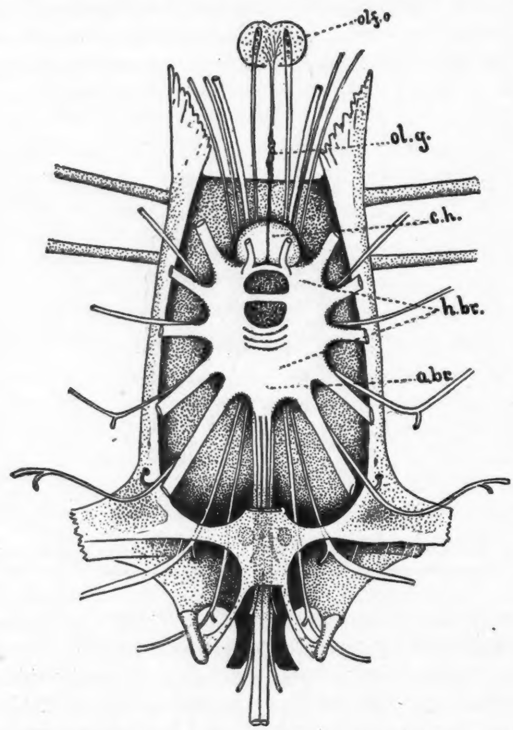

FIG. 6. — The endosternite of Limulus seen from the ventral side, with the brain and anterior part of the spinal cord in place, about natural size. The posterior part of the cranium is roofed over by a tough membrane, which on the sides gradually changes to the cartilaginous arches that help form the occipital ring, through which pass the spinal cord and several pairs of nerves. The sides of the cranium are perforated by two pairs of foramina, through which pass branches of the hæmal nerves. This cartilage is represented in Gaskell's diagram by the two bow-shaped cartilages on either side of *Ph.*

diagrams side by side (*Journal of Anatomy and Physiology*, Vol. XXXII, p. 556). One is a diagram of the cartilaginous skeleton of Ammocœtes, the other is labeled a "diagram of the cartilaginous

skeleton of Limulus" (Fig. 5 A). The diagrams do resemble each other very much no doubt, but the Limulus diagram can hardly be regarded as an accurate representation of the cartilages of that animal, as may be seen by comparing it with a drawing made directly from the object itself (Fig. 6). This figure is copied from one in a paper about to be published by Mr. Redenbaugh and myself, on the cartilages of Limulus, Apus, and Mygale. It is not easy to account for the construction of Mr. Gaskell's extraordinary diagram, since the endosternite of an adult Limulus is, roughly, two inches wide by three inches long, and several millimeters in thickness, a single heavy plate of tough cartilage, not readily broken or distorted. It has, moreover, been repeatedly figured and described, and Gaskell has himself dissected it and studied its histological characters.

Papers like the ones we have just reviewed are unfortunate. They are not a credit to the science of comparative morphology, and the interest in the whole subject of the origin of vertebrates suffers from the reaction induced by such efforts.

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